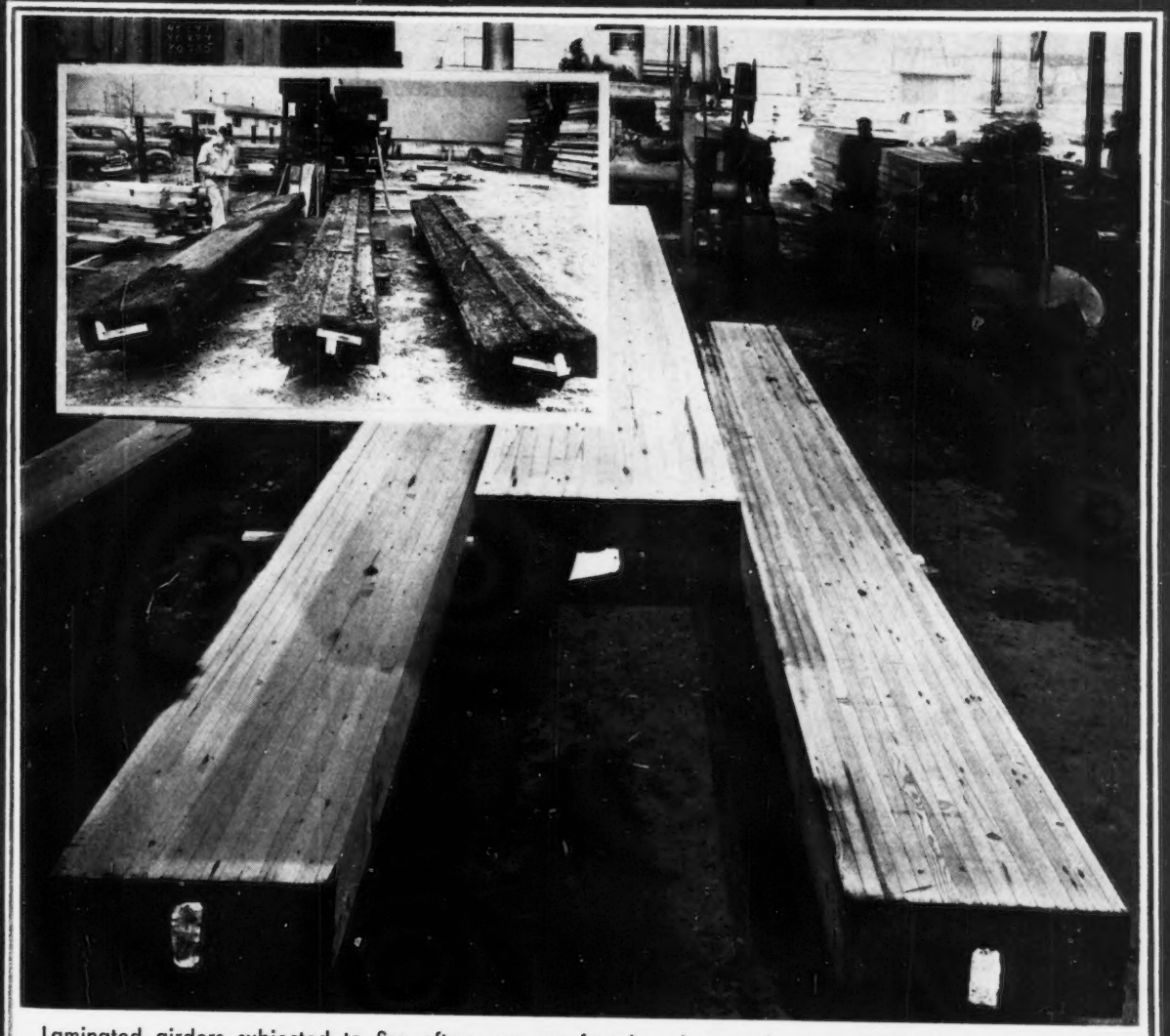
1956 TITLE, SUBJECT & AUTHOR INDEX—p. 31-A

Forest Products Journal

Vol. VI, No. 12 December, 1956



Laminated girders subjected to fire often are resurfaced and re-used as structural members—p. 489

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EXPERIENCE PROVES ONE GLUE BEST

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Found Best by Douglas Furniture Corporation for Laminate Bonding

The world's largest producer of metal dining furniture, Douglas Furniture Corporation, depends exclusively on Cyanamid's URAC 185 Resin Adhesive for the bonding of its Douglite* plastic laminates to plywood table tops. It has found that URAC 185 prevents "telegraphing" of wood grain to the laminate's surface and gives complaint-free service on its entire furniture line. *Experience has proved conclusively to Douglas that no other adhesive can do the job as well.*

You can benefit in production flexibility from the excellent performance of URAC 185 in both room temperature and hot-press operations at low pressure—and know that the bond is stronger than the wood it joins.

URAC 185 is craze resistant, and serves with equal dependability in laminate, plywood, and lumber core gluing. It is, without question, the finest urea-formaldehyde adhesive for furniture construction.

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FOREST PRODUCTS JOURNAL

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IMPORTANT FPRS DATES

Jan. 17–18: Inland Empire Section Meeting, Spokane, Wash.

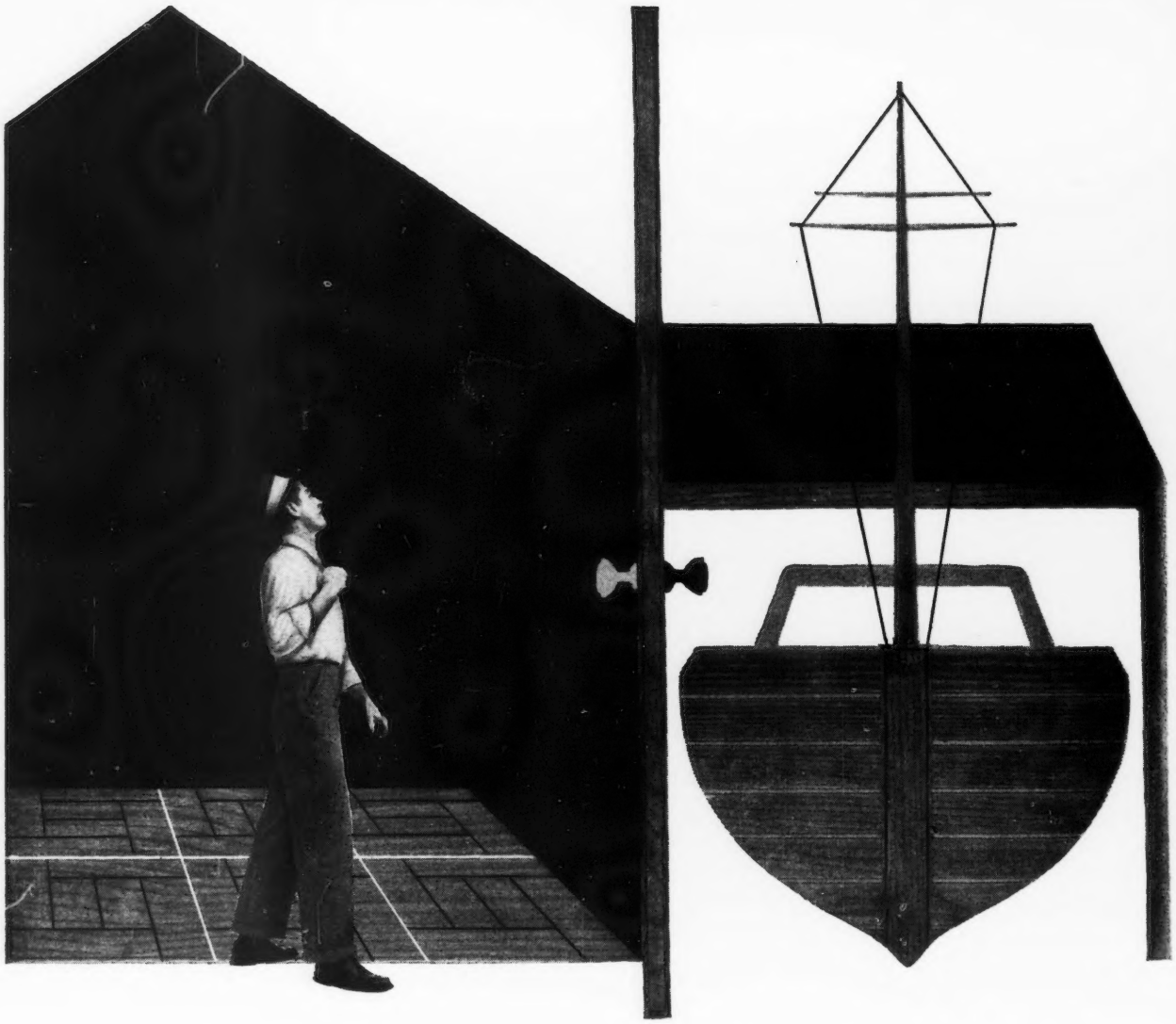
Feb. 4–5: Pacific Northwest Section Annual Meeting, Tacoma, Wash.

March 7–8, 1957: Eastern Canadian Section Annual Meeting, Queens Hotel, Montreal, Quebec.

June 24–28, 1957: Eleventh National Meeting, Buffalo, N. Y.

Send for Your FPRS Lapel Pin And Membership Certificate Now

Buy and wear an FPRS lapel pin. It will identify you as an active supporter of wood industry research and progress. The attractive green and gold pins are available for 75 cents. For an additional 25 cents, you can receive 8 x 10 frameable membership certificate. Send your order to Executive Secretary, Box 2010, Univ. Station, Madison 5, Wis.



For colorless waterproof bonding of exterior wood...

MELAMINE

Monsanto melamine resin, LAUXITE MF-300, provides a completely waterproof bond—for boats, exterior doors and paneling, scarfing lumber and parquet flooring.

In durability, Monsanto LAUXITE* MF-300 is comparable to the phenolics and resorcinols. Yet its color is so light there are no problems with conspicuous glue lines or staining through veneers.

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LAUXITE MF-300 bonds meet military as well as rigid civilian specifications. This resin is recommended as a straight adhesive (for either hot press or radio frequency gluing operations) or for upgrading urea formulations.

LAUXITE MF-300 can be economically formulated to meet your requirements for waterproof bonding. Write today for test samples and data sheets. Monsanto Chemical Company, Plastics Division, Room 471 Springfield 2, Mass.

*LAUXITE—REG. U.S. PAT. OFF.

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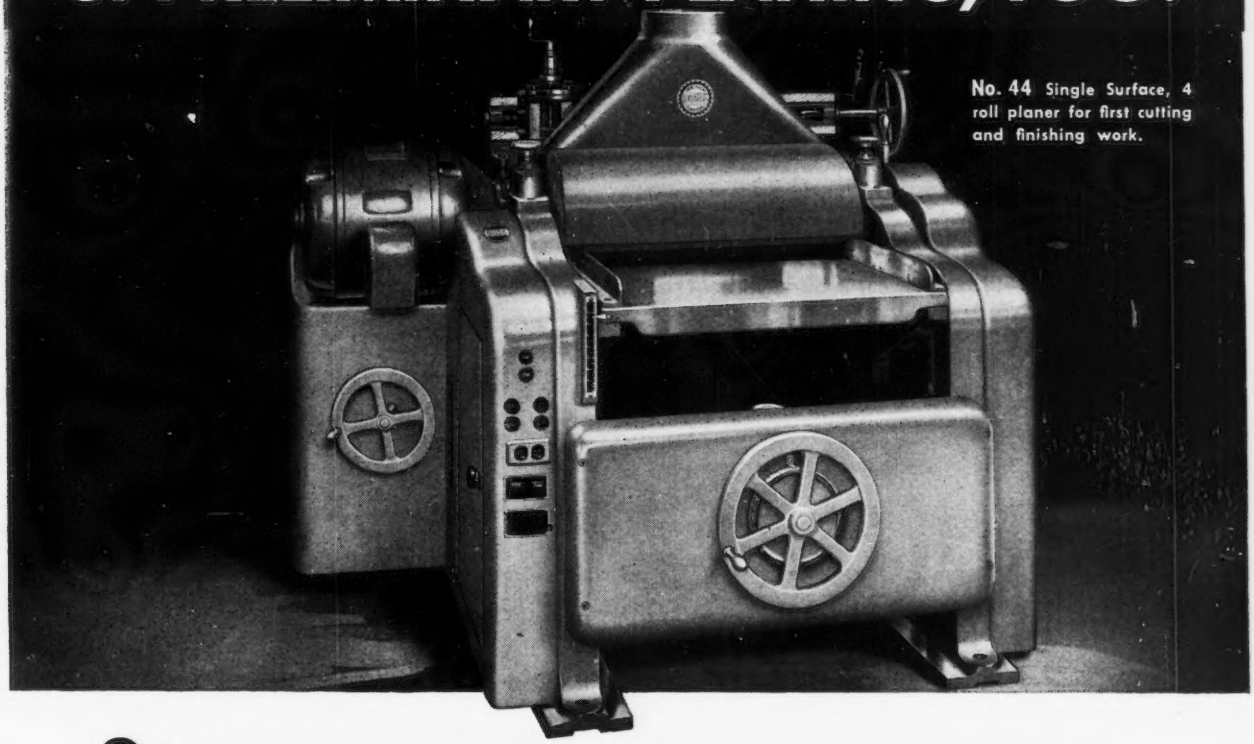
The BEST *FINISHING* PLANER is one that does the best job of *PRELIMINARY PLANING, TOO!*



No. 44 Single Surface, 4 roll planer for first cutting and finishing work.

ONE BASIC REASON FOR THIS is that the strategically located extra weight and strength which permits a planer to do an outstanding job of preliminary planing, with its greater strains and stresses, also provides the added stability so necessary to obtaining the finest finish planing.

Wherever it will contribute to greater accuracy, strength and stability BUSS planers are given extra size and weight. Frames are much heavier than competitive machines. Tables are wider and heavier. Table raising wedges are heavier and approximately 40% wider. Girts are thicker and heavier. Roll boxes are 50% longer. Cutterhead bearing housings are central over the frame. One piece grinding rail permits grinding knives within a fraction of a thousandth inch. The greater stamina thus achieved and their many exclusive, semi-automatic controls have made BUSS planers not only the finest of machines for preliminary planing but also the best to be had for finished planing.

Write for bulletins and judge for yourself.

6 MODELS 29 SIZES

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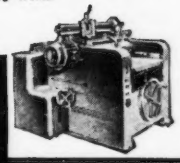
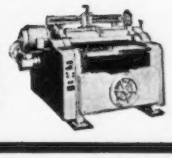
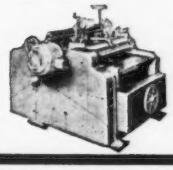
No. 4-L Single Surface, medium sized planer for first cutting and finishing work.



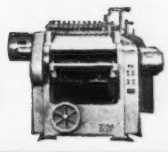
No. 66 Single Surface, 6 roll planer for first cutting and finishing work.



No. 88 Double Surface, 8 roll planer for first cutting and finishing work.



No. 55 Heavy duty Double Surfacer for planing rough lumber.



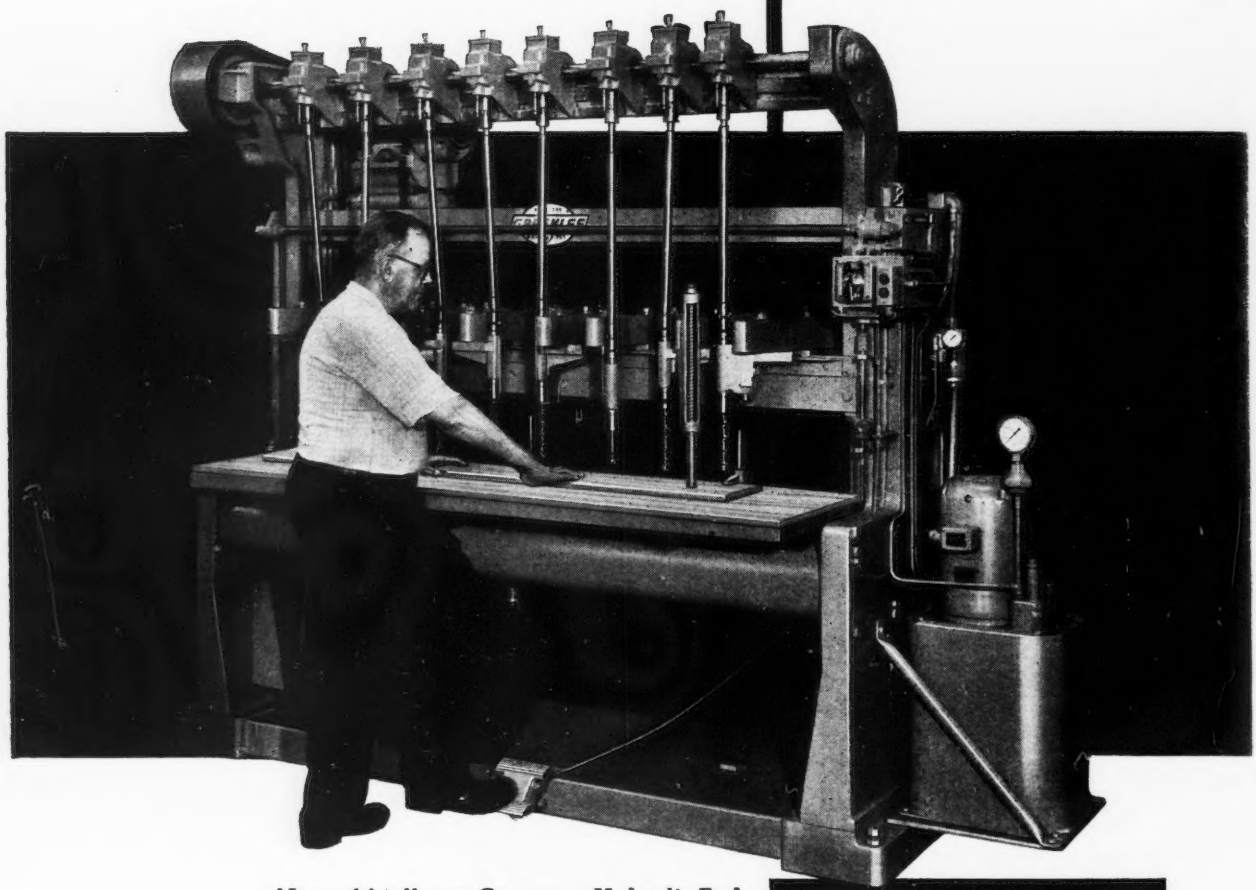
MICRO-SURFACER for planing hardboard and other very thin materials.

BUSS
SINCE 1862
MACHINE WORKS

PLANER SPECIALISTS EXCLUSIVELY

announcing . . . a new medium-range boring machine for furniture, cabinet, and other wood products manufacturing

the all-new Greenlee No. 308 HYDRAULIC-FEED Gang Borer



Now, this all-new GREENLEE *Hydraulic-Feed* Gang Borer with universal spindles brings you many advanced features for more efficient production. Work goes faster, better, because this *hydraulically fed* machine gives you accurate control for precision boring depth at all times . . . operation is simple . . . and a new standard of quietness and smoothness reduces operator fatigue to the minimum. Standard stroke range is 1″ to 12″ with infinitely variable feed rate. Operation is instantly controlled with a *single pedal* that has four positions for single cycle, continuous cycle, neutral, and emergency reverse. These, plus many other new features, add up to gang boring at its best. If your products call for multiple boring, it will pay you well to investigate immediately this highly efficient new machine.

CHECK THESE SPECIAL FEATURES

- ✓ **HYDRAULIC SPINDLE FEED** with variable control throughout entire feed range
- ✓ **INSTANT OPERATING CONTROL** with single, 4-position pedal at convenient location
- ✓ **STATIONARY TABLE HEIGHT** for easier, more efficient operation
- ✓ **SPIRAL-GEAR TOP-SECTION DRIVE**

The GREENLEE No. 308 HYDRAULIC-FEED Gang Borer is made in two nominal sizes: 4 feet and 6 feet. Write today for complete specifications.

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION

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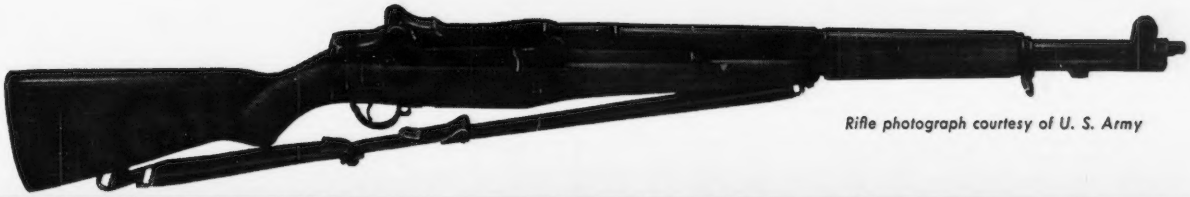
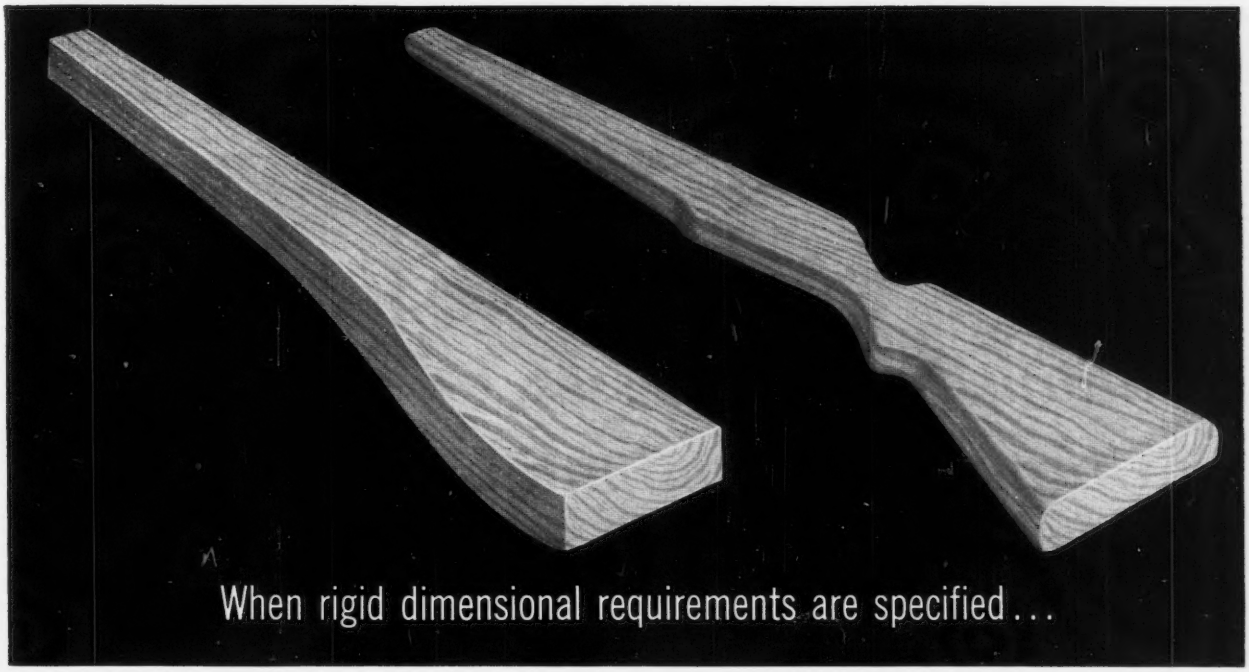


Rifle photograph courtesy of U. S. Army



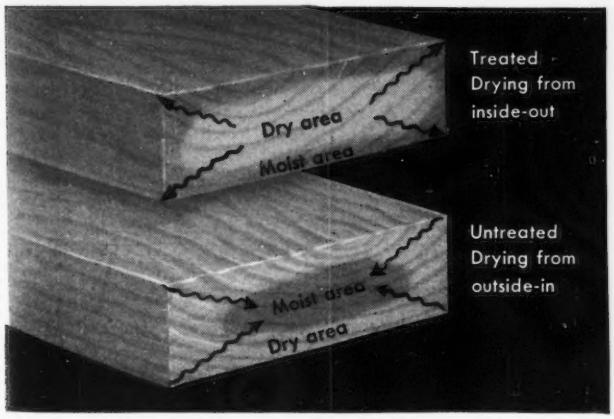
Use Morton Lumber Cure Treated Wood

Johnston-Crowder Manufacturing Co., Inc., kiln-dries rough blanks for the stock, front and rear handguards for the M-1 rifle. They also kiln-dry, machine and pack the forearm assembly for the Browning Automatic Rifle. 2⅝" walnut is used for all parts. Machining tolerances must range from as little as .004" to no more than .020".

Johnston-Crowder finds it pays to use Morton Lumber Cure. Morton Lumber Cure cuts drying time 10-12% and produces a stabilized product that can be precision machined to the rigid standards specified by the U. S. Army! What's more, kiln-drying rejects have been reduced 66⅔%!

Hundreds of fabricators now insist on lumber that has been treated with Morton Lumber Cure. They know from experience Morton Lumber Cure increases utilization of rough-cut lumber. Lumber also can be dried faster, kiln time and expense are reduced, with a more rapid turnover of inventory and capital.

What's more, Morton Lumber Cure is compatible with stain-preventing agents . . . will not affect gluability . . . machinability . . . color or finish. Morton Lumber Cure is non-toxic and non-corrosive.



HOW MORTON LUMBER CURE WORKS Morton Lumber Cure reverses the normal drying action. Untreated lumber dries from the outside in. Morton Lumber Cure dries lumber from the *inside out*. This controlled drying greatly reduces checks, honeycomb, warping, and other types of wasteful surface and interior degrade.

SEND FOR MORE INFORMATION TODAY!

Bay Chemical Company

DIVISION

Morton Salt Company

120 So. La Salle Street, Dept. FPJ-12, Chicago 3, Illinois

Please tell me how Morton Lumber Cure can help *me* increase my sales and satisfy customers.

Name_____

Title _____

Company_____

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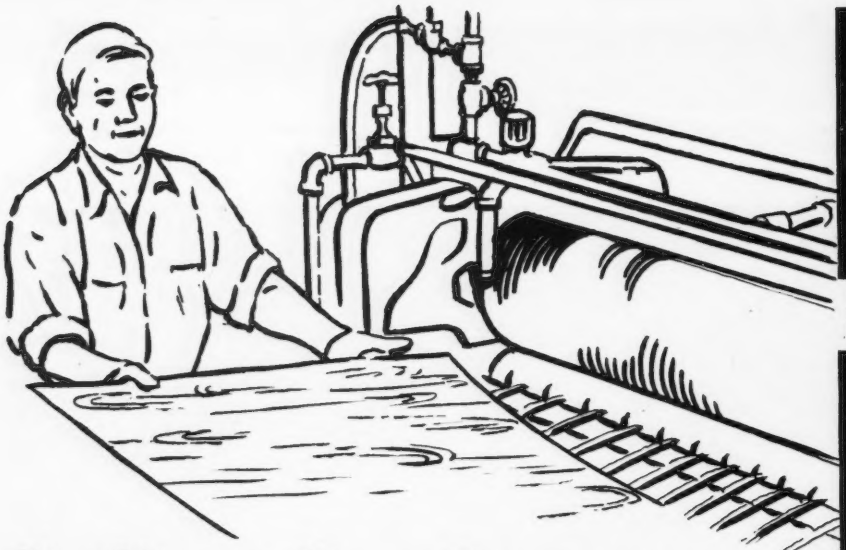
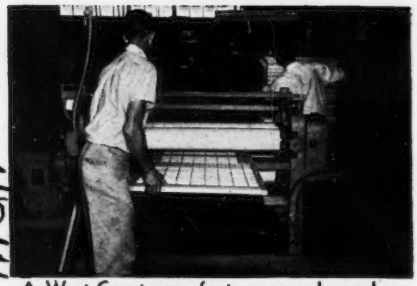
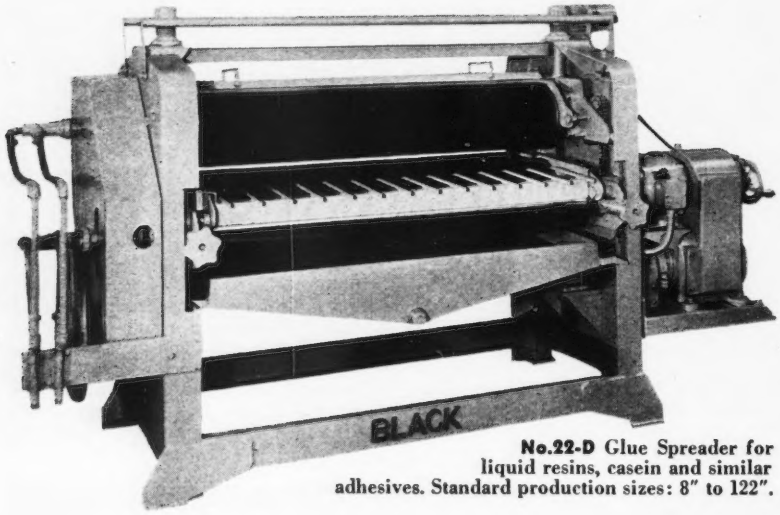




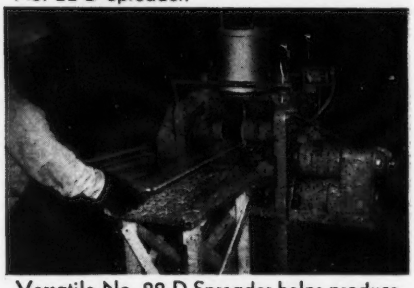
A West Coast manufacturer speeds production of hollow core flush doors with the No. 22-D, 50".

For glue testing and development work, a leading glue manufacturer depends on the No. 22-D Spreader.

Brilliant New Successes in Gluing and Laminating



No.22-D Glue Spreader for liquid resins, casein and similar adhesives. Standard production sizes: 8" to 122".

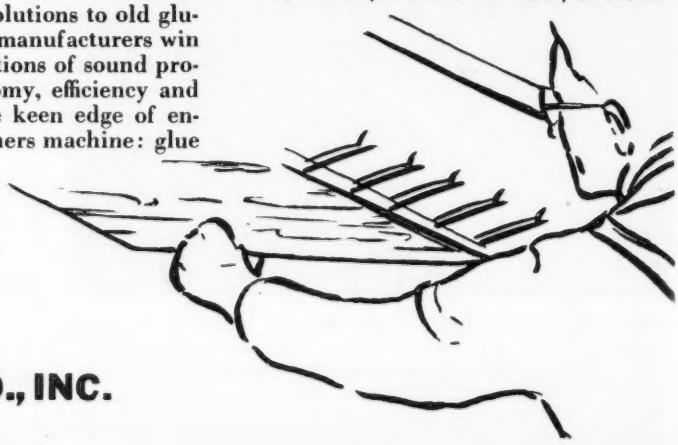


Versatile No. 22-D Spreader helps produce laminated beams and roof trusses at a California mill.

Fast, economical production of plywood in a Finnish plant. The No. 22-D, of course.

On production lines, in glue rooms and laboratories . . . Black Brothers Gluing and Laminating Equipment provides new solutions to old gluing and laminating problems. Helps cost-conscious manufacturers win new competitive markets, too, through new applications of sound production techniques. Preferred for its proven economy, efficiency and speed, the versatile No. 22-D Spreader reflects the keen edge of engineering skill incorporated into every Black Brothers machine: glue spreader, mixer, press or clamp.

Shouldn't you consider a Black Brothers installation? Write for our Supplement to Bulletin No. 11-A which gives construction details and specifications on the No. 22-D Glue Spreader.



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MENDOTA 8, ILLINOIS

How can you be sure of meeting wood glue specs?

Look to *Borden* for both the right data and the right glue!

As woodworking manufacturers know, reliable, up-to-date information is essential to meet commercial-standard, military and federal specifications for glue and plywood materials. The Borden Company is a convenient source for this data . . . supplying on request the most recent specification literature that not only lists recommended materials, but also gives the addresses of purchasing offices, shows amounts of glue needed per 1000 sq. ft. of glue joint (on wood), and tells how to estimate glue or molding-powder costs in preparing bids.

Furthermore, Borden can supply the *exact* adhesive needed for your job. For Borden specialists can apply 35 years of experience and experimentation with adhesives to your particular needs. These experts analyze your requirements, and then—by utilizing Borden's wide range of catalysts and modifiers—come up with the best glue for your job.

If you would like to receive informative data on both the right wood glue specs and the right glue formulations for your needs, contact The Borden Company, Chemical Division, Dept. FPJ-126, 350 Madison Ave., New York 17, N. Y.

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CHEMICAL DIVISION

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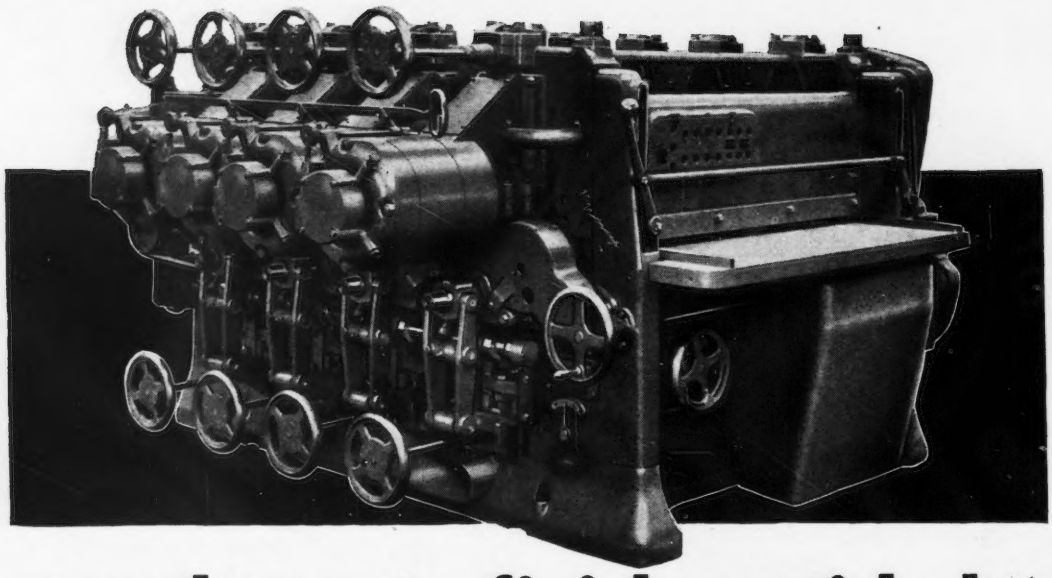

Improved way to finish particle board

eliminates chip-tearout problems

Mills using Yates-American Double-Deck Sanders come up with performance figures that are eye-openers!

You must agree that we at Yates-American can be unbiased in discussing the merits of surfacers versus sanders in chip-core operations. After all, we make both types of machines.

We feel that Yates-American surfacers are the finest. But — it is our honest opinion that *any* surfacer has *limitations,* when it comes to finishing particle board.

We estimate that about 60% of the end-use requirements for particle board call for a smooth finish you can get only from a *sander* — the Yates-American Double-Deck, in particular. Leading mills throughout the country back us up on that!

Does the Entire Job!

With the Yates Sander, finishing particle board is done in *one* operation:

It removes up to 3/16″ of stock (depending upon density of board) —at rates up to 50 feet per minute. It holds tolerances of less than ±.002″ over an entire sheet — *that we guarantee!*

There are no expensive carbide knives to joint, regrind, and reset. *No knife marks or chip tearout.*

Preferred by Leaders!

Leading companies like these have already purchased Yates-American Double-Deck Sanders:

American Parboard Corp.
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Rock Island, Illinois

Wabash Screen Door Co.
Minneapolis, Minnesota

Weyerhaeuser Timber Co.
North Bend, Oregon

Wynnewood Products Co.
Jacksonville, Texas

Don't you think a Yates Double-Deck Sander should figure in *your* particle board plans? Ask your nearby Yates-American man to make recommendations. Or write, wire, or phone us today at Beloit.

Yates-American
BELOIT, WISCONSIN

Branch Offices: Chicago, Illinois
High Point, North Carolina
Memphis, Tennessee
Portland, Oregon

WMMA — Woodworking Machinery Manufacturers' Association

First with the *Finest* in woodworking machinery. Established in 1883

MATCHERS • MOULDERS • SURFACERS • RIPSAWS • RESAWS • SANDERS

WW-9

How's this for SANDPAPER LIFE!

Here are some figures that are hard to believe — we blinked once or twice ourselves, when we first saw them. But they're fact — actual performance figures supplied to us by two reputable companies, names you'd recognize at once.

Both mills are finishing particle board with a Yates-American Double-Deck Sander and are removing up to 3/16″ of stock. This is what they report on sandpaper life:

First two pairs of drums.....	1200 to 1500 hours
Third pair of drums.....	500 to 700 hours
Fourth pair of drums.....	150 to 200 hours

We repeat — these are not *our* figures. They've been furnished to us by *two different mills* and have been confirmed and re-confirmed.

For the newest in coated abrasives... watch BEHR-MANNING!

Photo, Oakley Oscillating Edge Sander

Garnet Finishing Paper is tops for all your hand sanding operations.

Adalox Belts are favorites for cleaning up rough edges and glued areas.

Tufbak Paper is tops for smoother wet-sanding between coats.

Fast way to finish edges!

Banded edges of dresser tops are sanded in jiffy time with this modern coated abrasive application on the job. A smooth-cutting, long-lasting BEHR-MANNING Abrasive Belt running on an Oakley Oscillating Edge Sander makes this possible.

Though your finishing operations may be different, a modern coated abrasive method will assure increased production and better finishes every time. Ask your local BEHR-MANNING Field Engineer to demonstrate the advantages of abrasive belts — at a local BEHR-MANNING Demonstration Room or right in your plant. Call him today, or write Behr-Manning, Troy, N. Y., Dept. FP-12.

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for every type of plywood . . .

Roof or subfloor — You can expect uniform results in bonding structural plywood of all grades, when you use high quality RCI adhesives . . . tailored to specific needs.

RCI can fill all your adhesive needs *fast!*

● Whether you need "hot press phenolics," urea-formaldehyde or resorcinol resin adhesives, soybean or casein glues, Reichhold can supply you. *RCI has "the full line!"*

When it comes to delivery, you can count on Reichhold for *speed,* too! Widely located RCI plants and warehouses can fill all your needs for any of these adhesives without delay . . . by rail tank car or highway tank wagon.

And what about performance? It's excellent, for RCI control of adhesive quality extends to manufacturing its own basic raw materials such as phenol and formaldehyde.

When you have a technical problem, RCI's nationwide field service laboratories are ready to help you solve it . . . whether it involves a special glue for hot press, cold press, R/F, patching, splicing, utilizing wood waste or some completely new job.

Let Reichhold fill *all* your adhesive needs . . . technical information included!

Reichhold Seattle plant now also producing RCI Penta for wood preservatives!

Creative Chemistry . . .
Your Partner in Progress

RCI

REICHHOLD

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Phenol • Formaldehyde • Glycerine • Phthalic Anhydride
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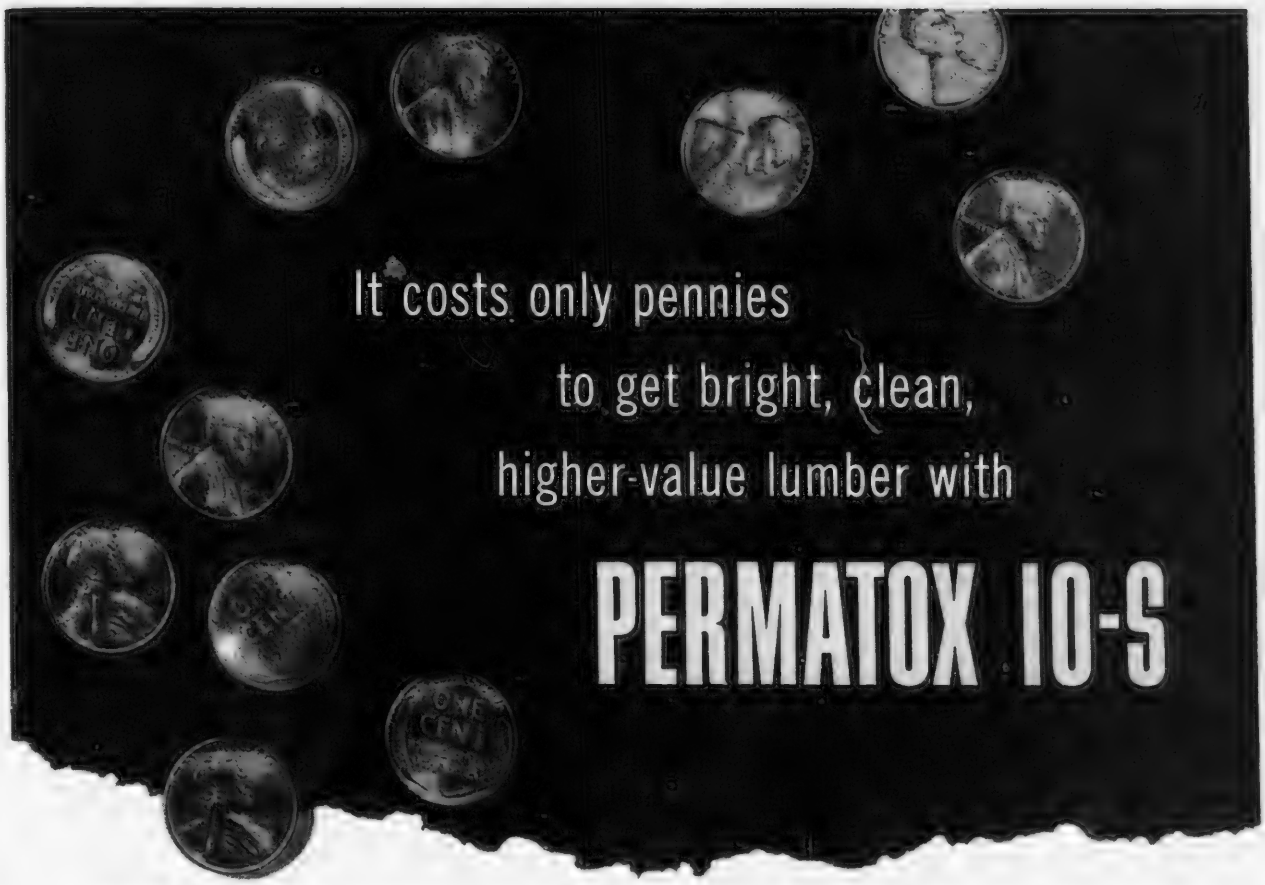
REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.



PERMATOX 10-S prevents stain and mold . . . makes lumber worth more

Permatox 10-S is the most effective chemical product yet developed for control of stain and mold in lumber during air seasoning. It saves many times its low cost by preventing expensive degrade which cuts profits.

Application of Permatox 10-S is simple with inexpensive dip or spray equipment requiring little labor. This improved sap stain chemical is practically dust-free and extremely easy for workers to handle and mix.

Mix with Ambrocide to stop insects, too

For full protection to lumber in the drying yard, Permatox 10-S can be mixed with Chapman Ambrocide. This prevents damage by beetles and other insects.

The value of Permatox 10-S has been proved in years of use by large and small mills and concentration yards. It assures highest prices for lumber.

Write Chapman Chemical Company for information on any problem in the field of wood preservation.

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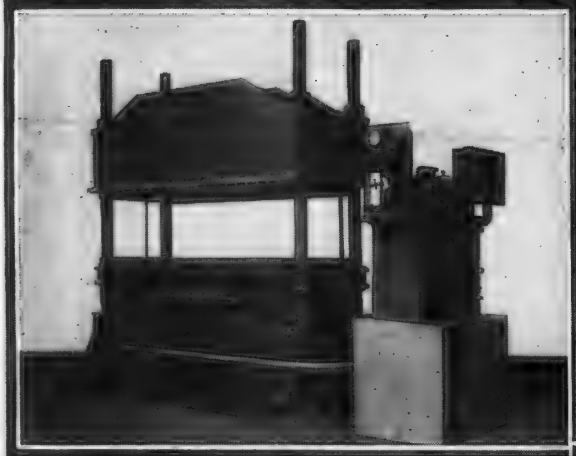

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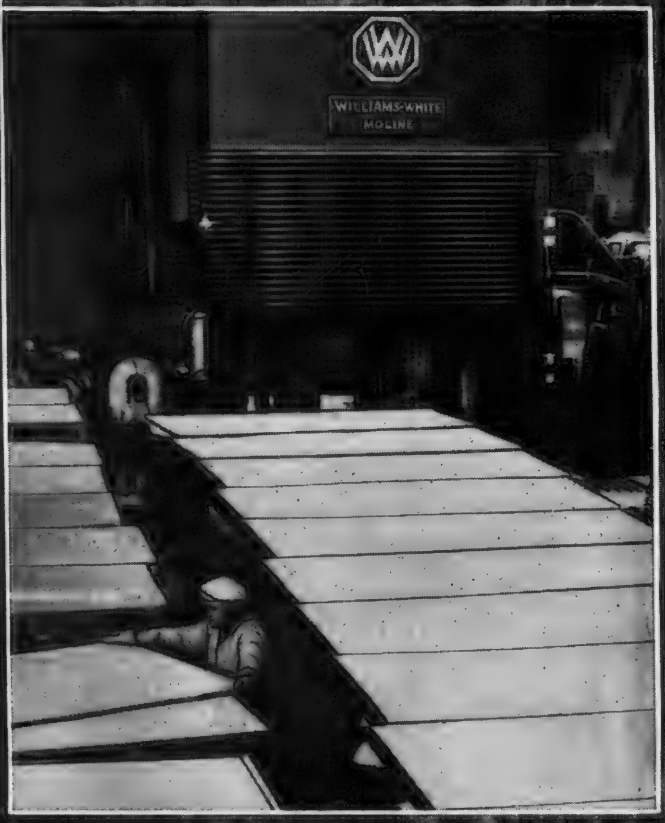

Above is illustrated a WILLIAMS-WHITE 250 Ton Hot Plate Press with platens 96" x 48" and adjustable daylight openings of 24", 30", 36" and 48". Equipped with automatic pushbutton control.

The press illustrated at right is a 20- opening plywood press, capacity 1485 Tons, with platens 106" x 56", in use in a plant in the Pacific Northwest.

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FPRS NEWS-DIGEST

Volume VI DECEMBER, 1956 Number 12

Record Outlay for Construction Predicted

NLMA Official Forecasts Increasing Markets for Lumber, Cites Industry's Research Requirements of the Future

The dollar volume of total new construction during 1957 is expected to eclipse even the record level of 1956, now figured at more than $44 billion, according to Leo V. Bodine, executive vice-president, National Lumber Manufacturers Association. This suggests an extremely favorable climate for most major building materials, he points out.

Other factors are expected to figure in the lumber picture during the coming year, Bodine says. Do-it-yourself activities promise to consume increasing quantities of the industry's production. Farmers appear to be working their way out of economic setbacks, which should help lumber markets in farm housing and service buildings. Landscaping with wood—fences, patios, windbreaks, screens, decking, etc. —should win more new friends as promotional efforts are increased. The $15 billion-a-year home improvement market should continue strong.

The housing credit shortage and its effects on new home starts were most important factors in the lumber picture during 1956. Total lumber production for the year is estimated at 37.6 billion board feet—4 per cent below 1955's high output of 39.1 billion. Partially offsetting a 5 per cent decline in softwood production, estimated at 30 billion board feet, was a 1 per cent rise in hardwood output, to 7.6 billion.

Lumber consumption for the year is estimated at 39.8 billion board feet, down 8 per cent from the level of 43 billion board feet in 1955. Softwood shipments this year were 1 per cent below production and new orders dropped 2 per cent below output. In hardwoods, shipments and new orders both trailed 1956 production by 5 per cent.

The NLMA executive cited these needs for the future: more research aimed at developing a greater variety of new products, greater log utilization, new efficiencies in production and distribution, more economical glues. Encouraging notes during the past year were more cooperative research by groups of lumber manufacturers, the stepped-up pace at which production of other forest products was added to sawmill operations, and the resurgence of wood windows in new home construction.

Prospects likely to have a major bearing on lumber industry affairs in 1957, according to Bodine, include: housing credit will remain as big problem of home builders but action is expected that will assure at least one million units of housing starts; more use of wood in home furnishings; increased sales of hardwood flooring; increased shipment of hardwoods to United Kingdom; federal aid to education; research in wood particle boards and glues; more off-site prefabrication in home building; and the new multi-billion dollar federal-state highway program.

Cross Tie Exports Rising, Commerce Executive Reports

The quantity of U. S. cross ties exported in 1956 will substantially exceed last year's level and may be the highest since 1947 or 1948, it was reported at the recent annual convention of the Railway Tie Association in Roanoke, Va. Cross tie exports and prospects were discussed by A. E. Fivaz, program executive for primary forest products, Forest Products Division, Business and Defense Services Administration, Dept. of Commerce.

Total exports in 1956 are expected to exceed 2.8 million ties, or the equivalent of 98 million board feet.

Prospects for 1957 appear bright, Fivaz said, because of the strong uptrend of railroad rehabilitation and extension, as well as continued maintenance, in all major areas of the world. They are enhanced by five outstanding ICA authorizations, three to Korea for 434,000 to 503,000 ties, and two to Spain for a total of 625,000 untreated ties.

J. P. Weyerhaeuser, Jr., Timber Firm President, Dies at 57

J. P. Weyerhaeuser, Jr., long-time supporter of FPRS activities and president of the timber company which bears his name, died Dec. 9 of leukemia. He was stricken with the fatal disease a month previously and had been hospitalized since Nov. 23.

Mr. Weyerhaeuser, known for his leadership in modern forestry practices and conservation, was principal speaker

at the Official Luncheon of FPRS' 1954 National Meeting in Grand Rapids, Mich. At that time he made the first announcement of the now-famed Stanford report of "America's Demand for Wood—1929–1975," the study of future wood needs sponsored by the Weyerhaeuser company.

He also was president of the Weyerhaeuser Steamship Co. and American Forest Products Industries, and was a director of Boeing Airplane Co. The Weyerhaeuser Timber Co. has been a supporting member of FPRS for several years.

1956 Seen as Best Year in Furniture Industry

The year just closing will definitely be the best in the history of the furniture industry, replacing 1955 as the top year, according to NAFM Executive Vice-President John M. Snow. There appears little doubt that 1956 will be 8 to 10 per cent ahead of 1955, as NAFM had predicted earlier in the year, he reports.

October shipments were up 19 per cent over September and 3 per cent greater than the same month last year. Orders for the month exceeded last year's by 6 per cent, with total orders 4 per cent ahead at the end of October. Unfilled orders, however, were at the lowest comparative level they have been this year, and 31 per cent under the October 1955 level.

Lumber, Pulp and Paper, Paperboard Statistical Reports Released

The Bureau of the Census, U. S. Dept. of Commerce, this month released advance reports on the 1954 Census of Manufacturers. Copies of each are available at 10 cents each from all Dept. of Commerce field offices, as well as the Washington office.

Lumber and Timber Basic Products, Series MC-24-1, includes selected statistics on logging camps and contractors, sawmills and planing mills, veneer mills, shingle mills, cooperage stock mills, and excelsior mills. Comparative figures for the last previous census in 1947 are given when available.

Pulp, Paper and Paperboard, Series MC-26-1, covers pulp mills, paper and paperboard mills, and building paper and board mills. Statistics include quantity and value of products shipped for both 1954 and 1947.

Chapman Chemical Co. Opens New Research Laboratory

A new research laboratory and library opened at the main plant of Chapman Chemical Co. in Memphis, Tenn. last month. The firm has operated its own pilot wood treating plant and chemical laboratory since 1949 and the new facilities are an extension of this service, according to Dr. E. A. Behr, vice-president in charge of research and development.

Seven chemists work in the new lab, which embodies latest developments in furniture, equipment, and construction materials. All furniture is natural oak with synthetic stone working surfaces, with stainless steel used on a portion of the work benches. The ceiling is composed of fiberglass and polyester resin film to be fireproof.

The new facilities will enable research chemists to explore the properties of petroleum solvent oils, the fields of synthetic resins and emulsifying agents, anti-stripping agents for asphalt and synthetic detergents, undercoatings for painting pressure-treated wood, and preservation of fiber insulating board.

California Laboratory Studying Properties of State's Hardwoods

Research designed to tap six billion board feet of hardwoods now standing unused in California forests is getting underway at the U. of California Forest Products Laboratory, according to Director Fred E. Dickinson. California tan oak, black oak, and Pacific madrone are among species being tested for basic mechanical and physical properties and for their gluing, drying, and machining characteristics.

All divisions of the laboratory will participate in the studies, Dickinson said. Arno Schniewind, section leader in timber mechanics, will determine strength properties. J. E. Marian, recently employed Swedish wood technologist, will test gluing properties. A. B. Anderson will experiment with new chemical processing methods. E. L. Ellwood, Australian scientist, will work on drying methods after his scheduled arrival Feb. 1 to join the California staff.

Industry Leaders Tour New Teco Lab Facilities

More than 200 representatives of the wood and chemical industries and government agencies attended the opening Nov. 8 of the newly expanded plant and facilities of Timber Engineering Co., Washington, D. C. Feature attraction was the new pilot plant and companion facilities for development and evaluation of wood particle board.

Following a luncheon, guests were taken on conducted tours of the expanded laboratory, including the new Moore dry kiln and demonstrations of special equipment used in measuring surface smoothness, ultrasonic testing of wood, studies of climatic influences on wood construction, and strength tests of wood products.

Of particular interest was the use of wood in the laboratory's new library area, conference room, and 11 private offices. More than a dozen hardwood and softwood species are used in wall paneling, flooring, doors, and trim.

New research laboratory at Chapman Chemical Co.

SOCIETY NEWS

Inland Empire Section Plans Winter Meeting in Spokane

William J. O'Connor, Deputy Director, Architectural Standards Division, Federal Housing Administration, Washington, will be among principal speakers at the winter meeting of the FPRS Inland Empire Section to be held Jan. 17–18 in Spokane, Wash. He will discuss proposed revised minimum property requirements as they apply to lumber grades and uses.

E. C. Wert, President of Thompson Falls Lumber Co., Spokane, is general arrangements chairman for the meeting. He will announce complete program details in the near future.

Composition Boards to Be Discussed at Tacoma Meeting

A discussion on wood composition boards will be a feature of the annual meeting of the Pacific Northwest Section Feb. 4 and 5 at the Winthrop Hotel, Tacoma, Wash. G. E. Tower, Forest Fibre Products Co., is arranging the panel session.

A second technical session will include papers by George Russell, West Tacoma Newsprint Co., raw material for pulp mills; Ray Currier, Oregon Forest Products Lab, high temperature veneer drying; T. E. Batey, Jr., Douglas Fir Plywood Assoc., effects of high temperature drying on plywood properties; and Dr. Donald H. Clark, Washington State Institute of Forest Products, developments in uses of red alder.

Technical sessions will be held each morning, with plant tours each afternoon, according to Vice-Chairman R. W. Wellwood. The West Tacoma Newsprint Co. will be among plants visited.

FPRS SECRETARIES met recently in Madison when Charles E. VanHagan (right), Executive Secretary in 1949–50, visited office of his successor, Frank J. Rovsek.

EXECUTIVE BOARD MEMBERS meeting in Madison last month made plans for 1957 and discussed other Society affairs. Left to right are: R. L. Hiller, North-Central Region; W. L. Irwin, Southeast; C. R. Lockard, Northeast; President-Elect Frank H. Kaufert; Past President Moss B. Christian; John D. Ritchie, Northwest; President Ralph H. Bescher; R. H. Berry, Southwest; Vice-President W. Jeter Eason, and W. R. Warner, South-Central.

Four More Firms Reserve Exhibit Space

More Than 80 Companies Expected to Display Equipment and Materials at 11th National Meeting in Buffalo

Four more companies have reserved space for the Wood Industry and Suppliers Exhibit to be held in conjunction with the FPRS National Meeting June 24–28 in Buffalo, N. Y. The Exhibit will occupy three rooms in the Hotel Statler, meeting headquarters, on the same floor and adjacent to the principal meeting rooms.

Exhibit Chairman Russell C. Deckert reports the four latest firms to sign for display space are: Peter Cooper Corp., Gowanda, N. Y.; Onsrud Machine Works, Chicago; Mater Machine Works, Corvallis, Ore.; and National Starch Products, New York. They join Kennametal, Inc., Latrobe, Pa., which was the first firm signed up among more than 80 firms expected to exhibit.

Peter Cooper Corp. is one of the oldest hide and animal glue manufacturers serving the wood industry. High-speed heavy-duty machines are the specialty of Onsrud Machine Works, recognized as one of the leading woodworking machinery manufacturers. Mater Machine Works specializes in automatic sawmill equipment, including carriages with remote control devices. National Adhesives division of National Starch Products is a well-known adhesives manufacturer, developed the Kwik-Klamp gluing process, and has just entered the particle board field with a product known as "Granite Board".

Plans are also taking shape for the technical program and other meeting activities. Eleven technical sessions are planned, with the tentative program to be released in the near future by General Chairman Charles R. Lockard, Northeast Forest Experiment Station, Upper Darby, Pa.

Because of the keen interest being shown, as well as space limitations in the exhibit area, all firms interested in reserving space should contact R. C. Deckert, State University College of Forestry, Syracuse 10, N. Y.

Executive Board Formulates Plans for Coming Year

A number of actions affecting the interests of FPRS members was taken at the semi-annual meeting of the Executive Board Nov. 29 at the Edgewater Hotel, Madison, Wis. All ten members were present.

Plans for approximately a 10 per cent increase in publication services to members were included in the proposed budget for 1957, which was approved. The budget calls for $100,000 of income and $97,000 of expenditures in the coming year.

The Executive Board voted to seek new office space convenient to the Forest Products Lab in Madison until our new office building is erected. (See President's Column, page 17–A).

Charlie Lockard reported on plans for what promises to be another outstanding National Meeting June 24–28 at Buffalo. F. H. Kaufert, program chairman, advised that five of eleven divisions planning technical sessions have already reported on their tentative programs. A question of individual member affiliation with Divisions was referred to the Division Chairmen's meeting at Buffalo.

Ed Roche, the Society's editor, reported on the status of papers being reviewed for future issues of the Journal. He indicated the institution of quarterly reports to section officers and publications committee personnel, advising of the status of all papers being reviewed for the Journal. He reported a diminishing backlog of papers due to rising standards for acceptance of papers. Total pages of the Journal increased from 850 in 1955 to 1,050 in 1956.

Ray Berry, Chairman of the By-Laws Committee, advised that to date two sections have adopted the proposed model by-laws. It was emphasized that for the purpose of legal responsibility all Section by-laws should be made uniform with those of the parent organization. This subject was referred to the Section Officers Advisory Committee meeting at Buffalo.

San Francisco was selected as the site of the 1959 National Meeting. The 1958 National Meeting was previously voted to be held at Milwaukee, Wis. Additional invitations from sections representing Baltimore, Montreal and Spokane will be considered for future years.

The need for a procedure whereby section meeting dates can be coordinated by clearance through the executive office is to be referred to the Section Officers' Advisory Committee at Buffalo.

A new series of section officers' handbooks to cover duties of officers, conduct of meetings, preparation and presentation of papers, membership promotion, etc. is in preparation and will be made available early in 1957.

A report by L. J. Carr, chairman of the committee to investigate publication of wood technology student recruitment literature, was read. He advised that the National Lumber Manufacturers Association at its recent annual meeting approved a plan for further study with the FPRS Industry-Education Division.

Summer Employment as Student Leads to Permanent Position

A summer position as a student obtained through the FPRS Employment Service led to full-time employment for J. S. Ranta, 1956 graduate of the University of Minnesota. He was given a summer job with Marsh & Truman Lumber Co., Chicago, during his junior year in college, and became a regular employee of the firm upon graduation.

Ranta is specializing in sales to contractors and industries througout the country, handling pine, fir, and hardwoods. An Oregon native, he is a veteran and formerly worked with contractors on the Iron Range in Minnesota.

FPRS SCOREBOARD

Our membership, gaining steadily, this month has reached 3,127 or an increase of 249 over a year ago. Together with our 256 subscribers, this means that the JOURNAL is now reaching over 3400 persons, a new record for the Society.

We are also happy to report that our entire national membership program—which is worked through the 13 Section membership chairmen—is making progress. To date we have state membership people working in 39 states and provinces. This is a good time to express, too, our appreciation to all FPRS members for their personal efforts in convincing other business associates to join and receive FPRS benefits.

Our Section membership standings look quite a bit different than in June when Eastern Canada, Pacific Northwest and Inland Empire took top annual honors. Now, at almost the halfway point, two new Sections are in the lead, but not so far that other enthusiastic Sections may not yet overcome them.

SECTION STANDINGS

	Members 6/1/56	Members 11/9/56	Net Gain or Loss	Wgtd. % Gain
Car.-Ches.	237	271	34	16
Great Lakes	208	227	19	10
East. Can	233	245	12	7
Mid-South	192	200	8	4
Upper Miss.	105	111	6	
No. Calif.	161	161	0	
Inland Emp.	97	99	2	
Northeast	525	524	–1	
Midwest	358	354	–4	
Fla. Ga.-Ala.	107	108	1	
Pac. N.W.	466	469	3	
Ohio Valley	83	84	1	
Pac. S.W.	67	65	–2	
Overseas	206	209	3	
	3045	3127	82	

SHORT COURSES

U. of California Schedules Forest Management School

How modern punch card techniques can be used in forest management will be featured at the Ninth Annual Forest Management Field School at the University of California. The course will be held Jan. 28 to Feb. 1, 1957 on the Berkeley campus. The U.S. Forest Service, California Forest and Range Experiment Station, and private industry are cooperating in giving the instruction.

Students at the week-long school will have the opportunity to follow the use of punch cards through several complete problems in forest management, including making a forest inventory, lumber grade recovery study, and growth study. Foresters will be shown how their job can be made easier by the use of machine records.

No tuition fees are charged for the course, further information for which can be obtained from Ed Gilden, Extension Forester, 25 Walter Mulford Hall, U. of California, Berkeley, 4, Calif.

Industrial Forestry Seminar Being Held in Berkeley

The first West Coast industrial forestry seminar will be held at Berkeley, Calif., Jan. 21–Feb. 1. The meetings will be sponsored jointly by the Yale and California forestry schools, with Prof. E. T. F. Wholenberg of Yale in charge. Discussion leaders will be prominent West Coast forest industry and business administrators.

The session at Berkeley is the second in a series of three similar seminars and is the only one scheduled for the West Coast. One was held in New Haven, Conn., in October and the third is scheduled there in March.

On the agenda will be such subjects as: forest inventories and stand structure studies; business organization in the forest industries; income taxes in relation to operating costs; public relations; integration, research, and product development; labor relations and collective bargaining; and the role of forest genetics.

Further information may be obtained from Dean H. J. Vaux, School of Forestry, U. of California, Berkeley 4, Calif.

Syracuse College Announces Dry Kiln, Gluing Courses

Short courses in dry kiln operation and wood gluing will be held concurrently Jan. 28–Feb. 2 at State University College of Forestry, Syracuse, N. Y. Prof. H. B. Gatslick will be in charge of instruction for the dry kiln course and Prof. A. H. Bishop will supervise the gluing course.

The latest and most flexible dry kiln facilities in the U. S. will be utilized in the dry kiln course, which will see the first use of the new Hugh P. Baker Memorial Wood Products Laboratory. The kiln equipment consists of two Moore and two Standard kilns and incorporates measuring and control devices to permit basic research studies not previously possible in dry kiln units.

Subjects to be discussed will include: structure of wood and its relation to drying; piling techniques; causes, effects, and controls of staining; insects that attack lumber in storage and use; importance of drying to gluing; types of kilns; moisture meters; heat and humidity; circulation and ventilation; steam systems and their efficiency; types, uses, and calibration of kiln instruments; drying veneers; plant storage and humidification.

The gluing course will include instruction in structure and properties of wood, veneer drying, staining and decay, selection and machining of wood, characteristics of adhesives, gluing principles, hot and cold pressing techniques, radio frequency heating, testing glue-bond strength, and quality control, with emphasis on causes of gluing defects.

Registration fee for each course is $75, with enrollment limited to permit individual instruction. Further information on each may be obtained from the College's Dept. of Forest Utilization.

See page 27-A for New Product News and New Publications

EMPLOYMENT SERVICE

Positions Offered

No. E–261—East Coast Naval Laboratory seeks wood technologists for New York City area. Salaries from $3,670 for recent graduates to $6,116 for experienced men. Work ranges from fundamental studies on foreign woods to diverse uses of wood in shipbuilding. (Jan.)

No. E. 265—Lab technician and quality control man needed for new particle board plant. West coast location. Prefer college graduate with background of lab technique, experience not necessary. Excellent opportunity for future. Will work alone, with guidance available. (Dec.)

Employment Wanted

No. 391—Sales or manufacturing in plywood, veneers, or forest products. New York State College of Forestry graduate, 1953. Age 26, married. Presently located in East. (Dec.)

HELP WANTED

WANTED — Technical Director for Hardboard Mill. Pulp and paper experience desirable but not essential. Salary commensurate with education and experience.

Send replies to
E-269, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
P. O. Box 2010
University Station
Madison 5, Wisconsin

FPRS Forest Products Journal

Vol. VI, No. 12
December, 1956

Effects of Insurance Rates and Building Codes on Wood Use[1]

ELON E. ELLIS

Vice-President and Director of Sales, Timber Structures, Inc., Portland, Ore.

A major problem confronting the entire industry is discrimination against wood in fire insurance rates and building codes. Compares effects of heat on wood and steel structural members and discusses progress being made in gaining more favorable position for wood in relation to insurance rates and building codes. Constant vigilance is essential to guard against further restrictions which affect markets for wood in all forms.

WOOD IS THE PARADOX of the construction industry. It is the oldest and most widely used of all building materials and, until recent years, was about the least understood. It has long been recognized for its versatility, beauty, and economy, but its unequaled value as an engineering material has been appreciated by all too few who select materials for the structural systems of modern buildings.

In addition to wood's recognized qualities of versatility, beauty and economy, it also has the qualities of safety and service.

The application of intensive research, modern technology, and engineering genius to this time-tested building material is responsible for a whole new concept of the uses for which wood is eminently suited. Standardization, stress grading, inspection, reliable design data, modern shop practices, and the establishing of a responsible timber fabricating industry all have contributed to the widespread and increasing demand for engineered timber construction. Wood is an engineered material in its finest sense and has an impressive record of performance.

The forest is nature's greatest benefactor to man and the wood of those forests is a most loyal servant to man. It does his bidding; he may use it for his comforts or pleasures or he may use it to destroy himself or his enemies. If properly used and cared for, it will not rot or rust. If he abuses it by subjecting it to loads in excess of those intended, it will give him an audible warning by cracking before it collapses. Wood offers both thermal and acoustical insulation. It has great strength with light weight; it is rugged yet easily worked; it is resistant to many acids and does not corrode. No other material takes and holds paint so well. While wood's natural pattern is often copied, it has never been matched.

In the last several decades the popularity of wood as a construction material has been seriously challenged by substitutes. These substitutes, however, have firmly entrenched themselves in the construction field and their promotion and acceptance has been nothing short of dramatic. In addition to the

[1] Presented at meeting of FPRS Inland Empire Section, Jan. 12–13, 1955, in Spokane, Wash.

The Author: Elon E. Ellis received B. S. in Civil Engineering from U. of Alabama, is registered engineer in Oregon and Washington. He is a member of Construction Specifications Institute and National Fire Protection Association, and Chairman, National Building Code Committee, American Institute of Timber Construction.

Fig. 1.—Sixteen glued laminated radial arches form the framework of 138-foot dome for new high school auditorium at College Station, Texas.

Fig. 2.—300-foot diameter dome covers new health and physical education center at Montana State College, Bozeman, which has seating capacity of 12,500.

basic rivals—stone and brick—we now are confronted with promotion and sales in the building material fields by steel, aluminum, plastics, and glass. These are just a few of the materials which today challenge wood as the leader in the construction field.

While the wood industry was undoubtedly slow to recognize the threat presented by these substitutes, the promoters of the substitutes utilized every promotional means that the timber industry failed or scorned to use. We now are fighting back, but it is a tough battle.

One of the prime targets in the battle is, and will continue to be, to see that wood is not discriminated against in building codes and fire insurance ratings.

The choice of the type of construction for any building housing any occupancy is dependent upon laws controlling construction and laws controlling location in communities. The first group of laws is usually designated as a building code. The second group is usually termed zoning ordinances and comprises two broad classifications. The first classification concerns fire districts which are established for the primary purpose of fire prevention, the second has for its primary purpose the comfort and reasonable relations of building occupants.

Engineered timber construction, as well as buildings constructed in whole or in part of wood, are directly affected by these laws. With so many codes throughout the United States it is natural that there should be wide variations of the provisions in them. Some requirements cover particular localities and these may be widely variant. However, most provisions which vary do so because of different interpretation of the code requirements.

The control of construction by building codes has long been established but in recent years another factor has arisen which in many cases tends to control the choice of types for a given occupancy or a given location. This factor is fire insurance rates. Admittedly, insurance for buildings for fire risk is not new. Insurance has, although perhaps not by that name, existed from ancient times when humans began living together as tribes and communities.

Fire insurance rates may affect the choice of construction types in three ways: nationwide disparity of rates, relative rates of various construction materials, and inter-connection with and direct effect upon building codes.

For identical conditions it may be that in one locality a building owner finds that a certain type of construction is economically sound and feasible; in another locality, that same type of construction might be deemed infeasible from an economical point of view. Likewise, the differences in fire insurance rates for the same building in two different localities are widely divergent. In many cases the fire insurance rates based on types of construction are at such variance that the effect is discriminatory and, as far as timber construction is concerned, adverse to its use when by other standards such construction type is the most suitable.

On The Cover

Inset photo shows glued laminated girders taken from a store building after having passed through a one-hour actual fire. The ledger on top of the two right hand girders was spiked on. Large photo shows same girders after removing spiked-on ledgers and surfacing off the char. The girders were re-used in a new building.

Public safety and welfare are the primary concern in writing a building code but unquestionably fire insurance rates have some effect in determine code restrictions and provisions. If insurance rates on normal sized and economical types of construction are excessive, the economic life of communities and cities are affected. Thus building codes and fire insurance rates are closely related.

Fire insurance rates should not affect building codes to the extent that codes become a lever or tool for forcing a particular type of construction upon a community and for forcing elimination of competitive types. Rates should be fair and non-discriminatory and their effect should be to insure amendments in codes so that any type of construction can be adopted to house any occupancy for which it is well suited without becoming a fire hazard.

When designing a building, the architect or engineer must choose construction materials which will best answer the clients' needs at the lowest cost, not only initially but for the life of the building. It is the over-all cost for the life of the building, including maintenance and insurance, which most often influences the choice of construction materials. Of these two, only insurance detrimentally affects engineered timber construction, since maintenance for this type of construction, when properly engineered is relatively minor and comparable to other types of construction.

Building codes have always listed building classifications with relation to their location and occupancies as Class 1, 2, 3, etc. Class 1 buildings were formerly referred to as "Fireproof"; Class 2 as "Heavy Timber or Mill Type Construction"; and Class 3 as "Ordinary Masonry" etc. Although not stated in the building code, these classes were used to denote comparative fire resistant characteristics of the building types.

The term "Fireproof" has been dropped for it is now a proven fact that no building is fireproof. Experience has shown that structural fire resistivity provides only a degree of protection to a building. The worst fires from standpoint of lives lost in recent years have occurred in so-called fireproof buildings.

Fairly recently building codes have adopted the terms "combustible" and "non-combustible" to describe the relative fire resistive characteristics of materials and buildings. These two words have caused more trouble than any other terms that affect the sale of engineered timber construction. They have led many people to think that if material will not burn, it is fireproof. They over-look the fact that heat caused by fire is far more destructive than the flames themselves. It is the job of the wood industry to direct attention to the fact that wood is certainly not responsible for all fires. Actually, most of the present day propaganda by competing materials is intended to impress the public and the insurance agencies alike that it is dangerous and unsafe to use timber in buildings under any circumstances.

Fire tests have proven that assemblies of wood or using wood as a component part can qualify for certain fire resistive ratings. It is difficult to understand, therefore, why there should be discrimination in comparing assemblies of materials when they are equal in fire rating, as established by standard tests.

Through the National Lumber Manufacturer's Association, American Institute of Timber Construction, Southern Pine Association, and West Coast Lumbermen's Association, we have had interesting discussions with insurance executives and rating bureaus. In most instances, they have appeared sympathetic with our arguments. However, to date we have received, with rare exceptions, no appreciable revisions in the rating schedules. The efforts of individual companies as well as these associations are being stepped up considerably. The insurance world knows of our work and any failure to gain more favorable attention to wood will not be due to lack of effort.

One association has recently added a trained, experienced insurance spe-

cialist to their staff. This man's first assignment is to analyze the construction and operation of various buildings owned by members of the association in an effort to reduce their insurance rates. Certainly considerable progress will be made, thereby putting this undertaking on a "pay as you go" basis.

Several years ago the states of Georgia and Alabama ruled completely against the use of wood in their school building program, even though lumber plays a large part in the economy of both states. After many meetings and discussions the cause appeared hopeless, but the various lumber associations have joined forces with the local lumbermen in those states and appreciable progress is now being made.

In discussion with insurance executives we find that they lack actual fire loss records covering heavy timber construction. Their loss records are grouped into only three classes of construction. This does not afford sufficient detailed information for proper loss-ratio analysis. The job is made more difficult by having to build up a considerable file to present to the insurance companies on the fire loss records of buildings using engineered timber construction as the structural system. The file is gradually being developed and it is hoped that soon it will be in shape for presentation.

In arguments supporting the fire resistivity of timber construction, it must be pointed out that when unprotected steel members are used to support floor and/or roof loads of a building, their lack of fire resistance makes them vulnerable to the combustible contents of the building occupancy. With practically all fires, the hazard arises from the contents of a building or from its immediate surroundings, rather than from the character of the building itself. Actual burning of the structural members of the building is only one of the problems. Expansion caused by intense heat and loss of form, strength, and other physical properties may be far more serious.

Mathew M. Braidech, Director of Research of the National Board of Fire Underwriters, in an address to the Convention of the Greater New York Safety Council in April 1954, stated: "There is also a lack of appreciation for the serious vulnerability of unprotected structural members of non-combustible building types, under fire conditions. Reference to the time-temperature curve of the aforementaioned standard fire test indicates a rapid rise of temperature, 1000° F. in 5 minutes, and to 1300° F. in 10 minutes after start of fire. Nothing that at 1000° . the compression and tensile strength f steel is about one-half that at at-

Fig. 3.—Glued laminated beam 9 x 27⅝ inches subjected to open fire test for one hour. Dotted lines indicate original section size. Based on ultimate strength of material, the beam is capable of continuing in service with a safety factor greater than 2 to 1.

mospheric temperatures, and that at 1200° F. it will be less than one-fourth, one should readily understand why bare steel structures will buckle and collapse in a matter of minutes under excessive heat."

At 1000° F. steel will expand so that a 100-foot section will be lengthened as much as 9½ inches. This explains why bare steel trusses exposed to heat from fire have been known to wreck masonry exterior walls, even though the temperature inside the building did not become high enough to ignite the combustible contents.

Wood has two properties which have an important bearing on fire resistivity. These are: natural insulation which retards progress of fire, and high tensile strength which increases with dryness.

Due to effective natural insulation of wood which prevents transmission of heat into the interior of the piece, seasoned structural timbers burn and char slowly—only one inch in depth in 33 minutes for Douglas-fir. Thus, in any fire of short duration, wood's strength well may remain unimpaired. Timber structural members frequently are simply cased in new lumber after a fire, for appearance purposes, and continued to carry their previous loads.

Clearing away the wreckage of steel structures twisted by fire damage is a costly process, involving specialized equipment and personnel. Damaged timber trusses on the other hand, frequently are repairable in place/or are easily removed by common labor.

The above statements are borne out by many firemen, fire chiefs, and others concerned with fire protection. Any fire chief will tell you that he would much prefer to have his men fight a fire in a building of timber construction than one using unprotected metal. With a wood deck the men can chop holes in the roof to vent the fire and thereby prevent it from spreading and at the same time, offer a means of fighting the fire. Firemen do not hesitate to go into a timber building, for their can judge accurately the severity of the fire at all times. They know that the timber will give them an audible warning beroe it collapses and therefore afford them opportunity to escape. No such warning is given by unprotected metal.

In spite of these recommendations by many fire protection authorities and building officials, we are still confronted with discriminatory insurance ratings. For example, the rates in connection with a building near Chicago for which the rating bureau determined the occupancy as a private garage and the building as a masonry structure with combustible roof over combustible supports, the insurance rate was 60½¢ per $100. If this same building had been designed without change except that a non-combustible roof and non-combustible supports substituted, the rate would have been 13½¢.

In Connecticut the rate for school buildings using unprotected steel for roof supports is 15¢ and for heavy timber 22¢ per $100 insurance. There is no differentiation allowed in Connecticut between heavy timber and light framing.

In four Southeastern states, for supermarkets of exactly the same design except in the roof system, buildings using heavy timber supports and 2½-inch thick deck are charged 110 per cent more for building insurance and 78 per cent more for content insurance than is unprotected steel with non-combustible deck.

These examples are factual and illustrate strongly the need for continued efforts to attain more favorable consideration for what we know to be a superior type construction.

Of interest to many associated with the timber industry are building code restrictions and exorbitant fire insurance rates applied to wood trim, plywood, and paneling. This item is commonly referred to and covered in building codes under "Flame Spread Characteristics". This, of course, refers to the ability of material to spread fire from one area to another. An item of great importance in this regard, and one that is in the majority of cases over-looked, is the effect of surface treatment of the trim materials. The spread of fire is seriously affected by paints and varnishes, regardless whether the material covered by these applications is combustible or non-combustible.

In a major city of the Northwest, the building code is currently being re-

vised. Upon inspection of the final draft presented for approval, it was found that the flame-spread classification as recommended practically eliminated the use of wood trim, wood paneling, and plywood in entryways and exitways of most buildings. In addition, it was noted that the area limitations for one-story buildings were appreciably reduced for those buildings using timber construction. These restrictions would seriously affect the market for wood in all forms. With help provided by a Building Code Consultant from NLMA and from WCLA, we have been successful in having this portion of the code rewritten to conform with the Uniform Building Code published by the Pacific Coast Building Officials Conference which is more realistic and not as critical of wood.

Constant Vigilance Needed

This example shows the importance of constant vigilance on the part of the wood industry. This occurred in a city located in the heart of the Douglas-fir industry, where certainly lumber is the most important phase of the economy, and still the promotion and propaganda spread by competitive materials had influenced preparation of this new code in their favor. We must be constantly alert, for in most municipalities it is difficult to have a code changed or amended after it is made a law.

Members of the Forest Products Research Society have a definite stake in the promotion of forest products and the betterment of its markets. It is urged that you contribute freely of your time and efforts in the insurance fight. Monetary assistance is, of course, important too, for AITC, NLMA, and similar organizations to continue their work. We must realize fully that we have a problem and that it will take the concerted effort of all to overcome it.

Statistical Sampling Proves Efficient and Accurate in Receiving Inspection

L. O. REED and R. T. WHITE

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A statistical sampling system is described which has proven successful in receiving inspection for veneer. Reasons are given for selecting the statistical form over other quality control methods. Operation of this form of sampling is described fully, including facilities and equipment needed for inspection, records required, and the method of handling rejects.

A CONSIDERATION OF ALL FACTORS involved in maintaining quality in industry leads to the conclusion that the establishment of an accurate receiving program is perhaps the most important. At the Marion, Va., plant of the Brunswick-Balke-Collender Co., which purchases large quantities of veneer, plywood, and hardware, the quality control program places the major emphasis on the receiving inspection. It has been found through experience that if material is good when received, the quality of the finished product can be maintained with a minimum of expense and effort.

There are two requirements of a good receiving program. It must be *accurate,* and it must be *economical.* A. V. Feigenbaum defines incoming material control as "the receiving and stocking, at the most economical level of quality, of only those parts the quality of which conforms to the specification requirements".[2]

If defective material is passed by the receiving inspector, it will not be detected until the material is delivered to the production line, which may be 30 to 60 days after having been received. Time is lost when the production department receives defective material, especially if there is no material on hand to substitute for the defective lot. In that case, production and shipping schedules are upset, since there is a delay in receiving a replacement order.

If defective material is not caught at the first operation, additional scrap will develop when the bad material is glued or otherwise permanently fastened to good material. In addition, it has been noted that operators who are usually conscientious workers tend to become careless when the material they receive to work with is not according to specifications, requiring additional work on their part and slowing them up.

Another disadvantage in failing to detect faulty material when it is received is that if the invoice has been paid and the account settled, difficulties may arise between the vendor and purchaser in settling for defective material.

If the time lapse between receiving and detecting faulty material is appreciable, it is not fair to expect the supplier to replace, without cost, all defective material. If the same material has been purchased from several different suppliers, as is usually the case in many companies, the vendor's identification is lost in the production department, leaving the purchaser to absorb the cost of the resulting scrap or the rework necessary to put the material into an acceptable category. The importance of accuracy in receiving can be summarized by stating that it is virtually impossible to attain the desired quality of the end product if the raw material is not according to specifications.

Receiving inspection, just as any other inspection, must be economical

[1] Presented at Session I, Quality Control, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

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Richard T. White received B. S. in wood technology from N. C. State College in 1953, has since been employed as inspection foreman and quality control engineer at the Marion plant.

[2] Feigenbaum, A. V. 1951. Quality control principles, and administration. McGraw–Hill Book Company, Inc., New York. p. 32.

because regardless of how much is spent for inspection or how much inspection is done, the value of the material is no higher after than it was prior to the inspection.

Statistical Sampling Favored

Statistical sampling is being used with a great deal of success at Brunswick's Marion plant in the inspection of incoming material, especially veneer. This form of inspection is used because 100 per cent inspection is neither economically feasible nor physically possible due to the large quantity of material being received. Statistical sampling is favored over spot checking, or 10 per cent sampling, because the quality control department considers it to be more consistent in discriminating between good and bad lots of material. Statistical sampling also requires less inspection in that material which contains an allowable defect percentage is passed 95 per cent of the time, thereby reducing the amount of 100 per cent inspection. Statistical sampling also requires a smaller sample size on lots with 1,000 or more pieces than would be required with 10 per cent inspection.

The 10 per cent sampling plan does not usually make allowances for any percentage of defects in a lot; when a defect is found, the lot is either rejected or, as is usually the case, is inspected 100 per cent. This failure to recognize that a small percentage of defects is apt to be present in even the best lots results in 100 per cent inspection of material when it would be more economical to pass the lot, even if the purchaser had to absorb the cost of rework or scrap resulting from the rejects.

This can be illustrated on a hypothetical lot by the use of the theory of probability as applied to industry by E. L. Grant.[3] If a lot with 5,000 pieces were inspected 10 per cent and rejected when one reject was found in the sample, lots containing 0.1 per cent defects would be rejected 39.5 per cent of the time; lots with 0.5 per cent defects would be rejected 91.8 per cent of the time; and lots with 1.0 per cent of defects would be rejected 99.3 per cent of the time.

Even when allowance is made for an acceptable percentage of defects, many lots will be rejected which fall within the allowable defects tolerance. Fig. 1 shows the inspection results of three different size lots when inspected 10 per cent with 2 per cent defects allowed. Lots 2 per cent defective will be accepted 82 per cent of the time when received in lot sizes of 100 pieces, 74 per cent of the time when received in lot sizes of 500 pieces, and 68 per cent of the time when received in lot sizes of 1,000 pieces. Lots 5 per cent defective will be accepted 61 per cent of the time when received in lot sizes of 100 pieces, 29 per cent of the time when received in lot sizes of 500 pieces, and 13 per cent of the time when received in lot sizes of 1,000 pieces. It can readily be concluded from Fig. 1 that the quality of lots passed when inspected 10 per cent is dependent on the size of the lot rather than on the percentage of defects in the lot.

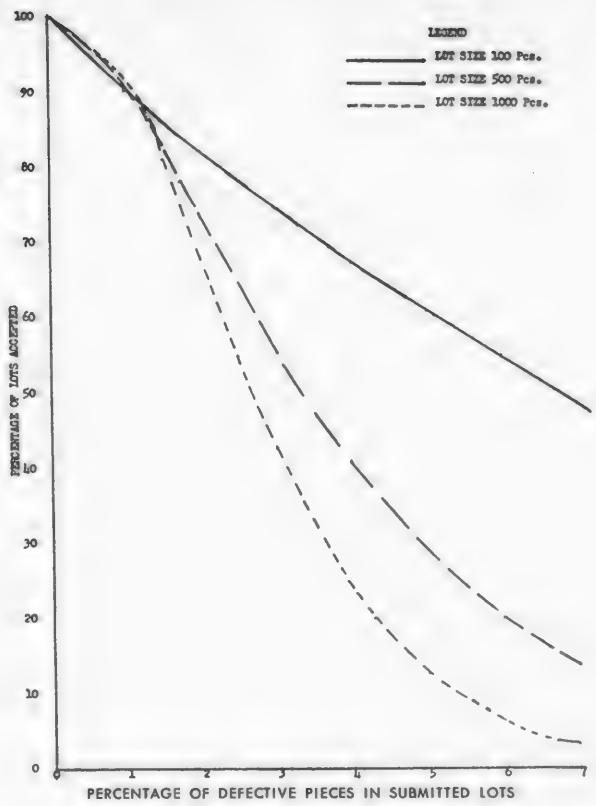

Fig. 1.—Results of 10 per cent inspection on three different lot sizes when 2 per cent defects in each lot is allowed.

Allowable Quality Level

Before statistical sampling can be used, it is necessary for the consumer to decide on an allowable defect percentage. This percentage is referred to in the sampling tables as the allowable quality level (AQL) and is defined as "the quality of a product such that the sampling plan accepts 95 per cent of submitted inspection lots of that quality".[4] (The definition varies slightly in other publications on sampling inspection.) If 95 per cent of the submitted lots which meet the AQL requirements are accepted, then 5 per cent will be rejected. This 5 per cent is called the "producer's risk".

In determining the AQL, the attainable quality of the material to be inspected should be taken into consideration. If the AQL is lower than the attainable quality, inspection costs will increase because many lots will be rejected and therefore require 100 per cent inspection. If the AQL is significantly higher than the attainable quality, the consumer will be accepting inferior material.

In determining the AQL to be used for inspecting veneer, the Quality Control Department at Brunswick inspected a few of the original shipments 100 per cent to determine the average percentage of defects. In addition, several of the suppliers were contacted and their viewpoints sought as to what would be a fair percentage of rejects. After careful consideration of all the factors, an AQL of 3 per cent was finally agreed upon.

In discussions with the suppliers on the establishment of an AQL, it was learned that few had any knowledge of statistical sampling, and those who had knowledge of it did not use it or understand the principles involved. After the suppliers were convinced that 95 per cent of the lots which contained 3 per cent defects would be accepted, they were all in favor of

[3] Grant, E. L. 1952. Statistical quality control. McGraw-Hill Book Company, Inc., New York. pp. 201–203.

[4] Freeman, H. A. Fridman, Milton, Mosteller, Frederick, and Wallis, W. Allen. 1948. Sampling inspection. McGraw-Hill Book Company, Inc., New York. p. 45.

statistical sampling, for their own protection as well as Brunswick's.

Selecting Sampling Tables

After an AQL had been reached, it was necessary for the consumer to decide on a set of sampling tables to be used. The Quality Control Department at Brunswick used sampling tables by Freeman, et al.[5] Tables are provided in this book for the three types of sampling—single, double, and sequential sampling, sometimes called multiple sampling.

Table 1 shows how each of these plans operates on a lot of 5,000 pieces inspected with an AQL of 3 per cent. The single sampling plan allows for a sample size of 225 pieces; the lot is accepted if 11 or less defective pieces are found and rejected if 12 or more defective pieces are found. The double sampling plan allows for an original sample of 150 pieces; the lot is accepted if 7 or less defective pieces are found and rejected if 19 or more defective pieces are found. If the sample contains 8 to 18 defective pieces, a second sample of 300 pieces is inspected. The lot is accepted after the second sample is completed if 18 or less pieces are defective and rejected if 19 or more pieces are defective. The sequential sampling plan functions like the double sampling plan except that it is possible to take up to eight separate samples before a definite acceptance or rejection quantity of defects is found.

The double sampling is used in the receiving department because less inspection is required on lots which are significantly good or bad and also because lots are never rejected unless at least two defects are found in the sample. Double sampling is used in preference to sequential sampling because the original sample size of the sequential tables is very small, and it is extremely difficult to pull at random a sample that is representative of the lot.

How Double Sampling Works

Tables 2 and 3 show the double sampling tables used in receiving inspection. Table 2 has five inspection levels which may be used in determining the sample size. The risk of rejecting a good lot is 5 per cent for all levels, but the risk of accepting a bad lot varies. The higher the level, the larger the sample size and the less risk of accepting a bad lot. Inspection level III is considered normal inspection. If a supplier has a good record and rarely has a shipment rejected, level II is used. This is referred to as "reduced inspection". If a supplier has frequent shipments rejected, level IV is used, and this is called "tightened inspection".

A code letter is obtained in Table 2 from the lot size and inspection level. In Table 3 the code letter gives the sample size and the requirements for acceptance or rejection under the AQL column in which the predetermined per cent defective falls. An AQL of 3 per cent falls into the class 2.2 to 3.2.

The graph in Fig. 2 shows the inspection results of the double sampling plan in Table 1. Lots which are 3.2 per cent defective will be accepted 95 per cent of the time; lots 5 per cent defective will be accepted 55 per cent of the time; and lots 8 per cent defective will be accepted 6 per cent of the time.

Although not indicated by Table 3, this sampling plan has an average outgoing-quality (AOQ) as well as an AQL. The AOQ is the average quality of accepted lots, and rejected lots which are inspected 100 per cent and are theoretically perfect. If 100 lots of 5,000 pieces were inspected and if all lots were 5 per cent defective, Fig. 2 shows that 55 of these lots would be accepted and 45 rejected. If the 45 lots were inspected 100 per cent and all defective material re-

[5] See footnote 4.

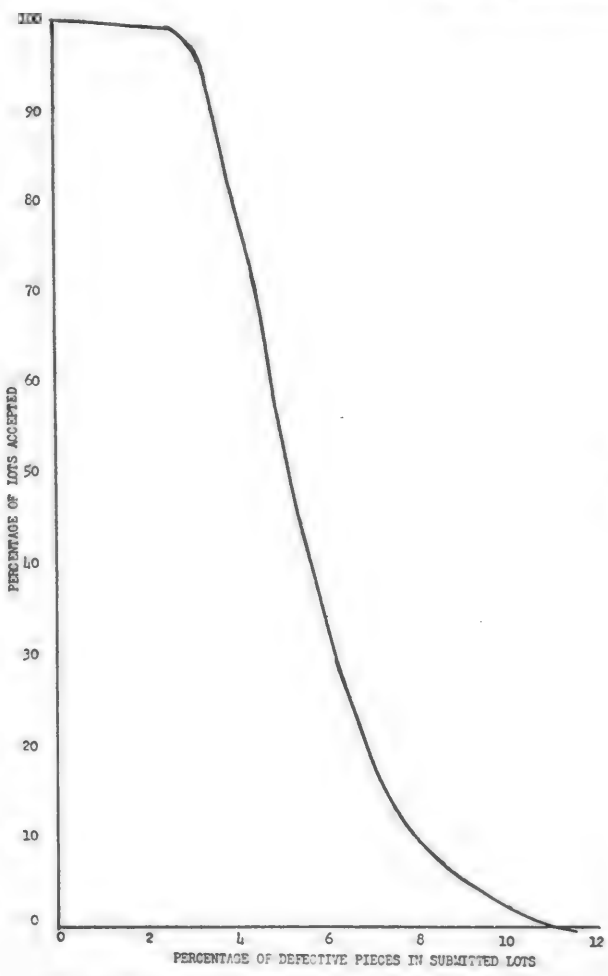

Fig. 2.—Results of the double sampling plan in Table 1.

Table 1.—EXAMPLE OF THREE STATISTICAL SAMPLING PLANS USING INSPECTION LEVEL III FOR A LOT SIZE OF 5,000 PIECES

Type of Sampling	Sample	Sample Size	Combined Samples		
			Size	Acceptance Number	Rejection Number
Single	First	225	225	11	12
Double	First	150	150	7	19
	Second	300	450	18	19
Sequential	First	50	50	0	5
	Second	50	100	3	8
	Third	50	150	5	11
	Fourth	50	200	8	13
	Fifth	50	250	10	15
	Sixth	50	300	13	18
	Seventh	50	350	15	20
	Eighth	50	400	19	20

Table 2.—SAMPLE-SIZE LETTER, BY INSPECTION LEVEL AND SIZE OF INSPECTION LOT

Size of Inspection Lot	Sample-size letter for inspection level				
	I	II	III	IV	V
Under 25	A	A	B	C	D
25– 50	A	B	C	D	E
50– 100	B	C	D	E	F
100– 200	C	D	E	F	G
200– 300	D	E	F	G	H
300– 500	E	F	G	H	I
500– 800	F	G	H	I	J
800– 1,300	G	H	I	J	K
1,300– 3,200	H	I	J	K	L
3,200– 8,000	I	J	K	L	M
8,000– 22,000	J	K	L	M	N
22,000–110,000	K	L	M	N	N
110,000–550,000	L	M	N	N	O
550,000 and over	N	N	O	O	O

moved, the average outgoing quality would be

$$\frac{.05\ (55) + 0(45)\ (5{,}000)}{100}$$

equals 2.75 per cent. The average outgoing quality can be determined for any per cent defective merely by multiplying the acceptability on the vertical axis of Fig. 2 by the per cent defective on the horizontal axis (55 x .05% equals 2.75). If this is done, a curve can be drawn showing the AOQ for all qualities of incoming material. Such a curve is shown in Fig. 3 for the inspection results illustrated in Fig. 2. The peak of the curve in Fig. 3 is 3.2 per cent and is referred to as the "average outgoing-quality limit" (AOQL), which is defined as "the worst average quality to be expected in the accepted product, no matter what may be the quality of the product submitted".[6]

The double sampling plan in Table 3, for an AQL class of 2.2 to 3.2 per cent, has an AOQL class of 7.0 to 11.0 per cent for code letter B; 5.0 to 7.0 per cent for code letter C; 3.5 to 5.0 per cent for code letters D through G; and 2.5 to 3.5 per cent for code letters H through M.

Other sampling tables which are widely used are found in the following publications:

1. Dodge, Harold F. and Roming, Harry G. 1944. Sampling inspection tables, John Wiley and Sons, Inc., New York.

2. Anon. 1950. Mil–Std–105A, Sampling procedures and tables for inspection by attributes. Superintendent of Documents, Government Printing Office, Washington, D. C.

[6] Peach, Paul. Industrial statistics and quality control. Edwards and Broughton Co., Raleigh, N. C. p. 114 (Second ed.)

Inspection System

After the selection of a sampling plan, it is necessary to educate the inspector in the interpretation of the tables, the importance of picking a sample at random, exact definitions as to what constitutes a reject, and information on recording the inspection results.

The tables are relatively easy to understand and little time is required for instructions on their use. However, experience has indicated that educating an inspector in the selection of a random sample is not so simple. The sample, in order to give an accurate indication of the lot quality, must be picked at random through the entire lot.

Picking the sample often requires more of the inspector's time and energy than the actual inspection. In taking the easy way out, the average inspector is inclined to pick more pieces from an easily accessible location than from a less accessible one. For example, veneer is received in crates containing 500 pieces. The inspector is required to open each crate in a particular lot, randomly pick a portion of the sample, and nail back the crate. If the inspector does not understand that an accurate inspection is dependent on a random sample, he is likely to consider the extra work a waste of time, especially when material is being received faster than it is inspected, and devise short cuts by taking more pieces out of fewer crates. For this reason, the inspection supervisors continually stress the importance of a random sample to the inspectors using statistical tables.

Statistical sampling is only the first step in assuring the quality of incoming material. The tables are only tools and will not give consistent results if the inspector using them is not consistent in rejecting material which does not meet specifications and in accepting material that does. To obtain this consistency, the inspector must be supplied with as much information on the material as is necessary in order to reduce to a minimum his responsibility in deciding which material will pass inspection.

To achieve this, the receiving inspectors are given complete specifications, blueprints, and samples to guide them. The veneer inspector is given the same specifications that are sent to all suppliers, giving the species, tolerances on dimensions, limitations on mineral streaks, knots, splits, moisture content, etc. All face grade veneer for school furniture is specified "select white" and to guide him, the inspector is given samples showing the acceptable color range and the degree of discoloration allowed.

Inspection Facilities and Equipment

The receiving inspector requires adequate space, facilities, and tools in order to function efficiently and accurately. Inspection space often is not included in floor layouts, especially in the receiving department. When this is true, the receiving inspection is at the mercy of the receiving department, and if the space he is using is not needed, he is fortunate. If it is needed, it is necessary for him to move. Each move of this nature is usually to a smaller and less desirable location. To

Table 3.—DOUBLE-SAMPLING PLANS

Sample-size letter	Sample	Sample Size	Combined Sample Size	Acceptable-quality Level (% defective) 0.65–1.2 Ac	Re	1.2–2.2 Ac	Re	2.2–3.2 Ac	Re	3.2–4.4 Ac	Re	4.4–5.3 Ac	Re	5.3–6.4 Ac	Re	6.4–8.5 Ac	Re
A	First	3	3											0	2	0	2
	Second	6	9	*		↓		↓		↓		↓		1	2	1	2
B	First	7	7							0	3	0	3	1	3	1	4
	Second	14	21	↓		↓		↓		2	3	2	3	2	3	3	4
C	First	10	10					0	3	0	3	1	3	1	4	1	6
	Second	20	30	↓		↓		2	3	2	3	2	3	3	4	5	6
D	First	13	13			0	3	0	3	0	5	0	5	1	6	1	6
	Second	26	39	↓		2	3	2	3	4	5	4	5	5	6	5	6
E	First	20	20	0	2	1	3	1	4	1	5	1	6	2	7	3	8
	Second	40	60	1	2	2	3	3	4	4	5	5	6	6	7	7	8
F	First	25	25	0	3	1	4	1	5	1	6	2	6	2	9	2	11
	Second	50	75	2	3	3	4	4	5	5	6	5	6	8	9	10	11
G	First	35	35	1	3	1	5	1	6	2	7	2	9	3	10	4	13
	Second	70	105	2	3	4	5	5	6	6	7	8	9	9	10	12	13
H	First	50	50	1	4	1	6	2	7	3	10	4	11	5	13	6	17
	Second	100	150	3	4	5	6	6	7	9	10	10	11	12	13	16	17
I	First	75	75	1	6	3	6	4	9	5	12	6	15	6	19	8	24
	Second	150	225	5	6	5	6	8	9	11	12	14	15	18	19	23	24
J	First	100	100	2	6	3	10	5	12	6	17	8	20	8	26	11	31
	Second	200	300	5	6	9	10	11	12	16	17	19	20	25	26	30	31
K	First	150	150	3	8	5	14	7	19	9	24	11	29	14	34	16	44
	Second	300	450	7	8	13	14	18	19	23	24	28	29	33	34	43	44
L	First	200	200	4	10	6	17	9	25	11	33	14	38	18	45	↑	
	Second	400	600	9	10	16	17	24	25	32	33	37	38	44	45		
M	First	300	300	5	16	8	26	12	36	16	48	↑		↑		↑	
	Second	600	900	15	16	25	26	35	36	47	48						
N	First	500	500	7	24	14	41	↑		↑		↑		↑		↑	
	Second	1,000	1,500	23	24	40	41										
P	First	1,000	1,000	14	44	↑		↑		↑		↑		↑		↑	
	Second	2,000	3,000	43	44												

Ac—Acceptance number
Re—Rejection number
* —Use single-sampling plan

↓ Use first sampling plan below arrow
↑ —Use first sampling plan above arrow

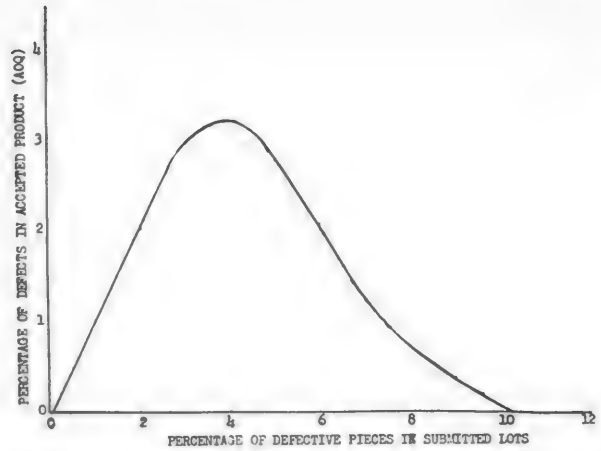

Fig. 3.—Average outgoing quality after all rejected lots are inspected 100 per cent and all defects removed.

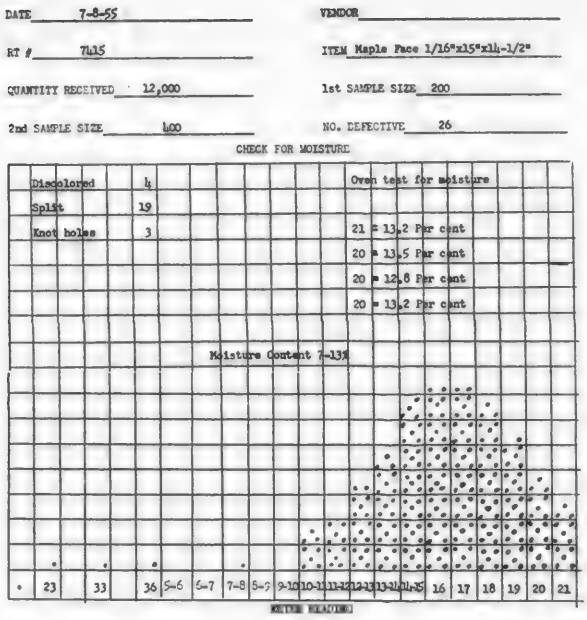

Fig. 4.—Form used by receiving inspector at Brunswick-Balke-Collender Company for recording statistical sampling results for veneer.

overcome this, all inspection areas at our plant, including receiving, are clearly lined off with paint, and this area is not used for any purpose except inspection.

The inspector requires adequate facilities such as lights, air hoses, and outlets for electrical tools which might be needed in the course of inspection. At one period in the beginning of the school furniture production, it was noticed that the face grade material being delivered to production was darker than desirable. This same material, when examined under two of the fluorescent lights at the receiving inspection station, appeared to be within the allowable color range. The trouble was not in the amount of light at the station but in the position of the lights. After several trials, it was found that one light with two fluorescent bulbs 85 inches above the floor directly over the inspector's head and a similar light three to four feet in front of the inspector, a foot above his head and tilted at a 45 degree angle, gave the best results. Some of the veneer suppliers, after seeing the results of the lighting arrangement, immediately put it to use in their final inspection of veneer.

When gauges, meters, and other measuring devices are used in the examination of incoming materials, the inspection results will be no more accurate than the accuracy of the equipment being used. For this reason, it is necessary to supply the inspector with tools that are adequate to do the necessary checking. It is important that tools such as gauges and meters be checked periodically in order to maintain the accuracy desired.

Instruments such as moisture meters should have the batteries replaced at regular intervals, and meter readings should be checked periodically with oven checks in order to determine the accuracy of the meter.

Because high frequency presses with five cavities side by side are used in molding school furniture seats and backs, it is necessary that veneer being received be held to a moisture content range of 7 to 9 per cent in order that all cavities will have equal temperatures. If veneer with a greater variation than 2 per cent moisture is used, a high percentage of delaminations and blows results from uneven heating. Separating lots which are within the specified moisture content range from lots which are not is perhaps as difficult a task as could befall any receiving inspector, but this task is being accomplished by following the steps outlined in this paper.

The meters used successfully at the plant for years in checking the moisture content of veneer for hot press and cold press gluing were not considered accurate enough for high frequency gluing, and a new meter was purchased. Because moisture meter readings vary with the species of veneer being checked, the accuracy of the meter was increased by preparing a conversion chart for the species of veneer received. To maintain this accuracy, almost daily oven checks are made and the results are compared with the conversion charts. Batteries are replaced every six months, even though they might last as long as a year without causing any difficulties. One reason for this extra precaution is that batteries are not available locally, and two weeks are usually required to receive replacements.

It is helpful if the inspector keeps written records of all lots inspected, containing information such as the vendor's name, type of material being received, number of samples and their sizes, the quantity of rejects, reasons for rejection, and other information needed to identify the material absolutely, such as the purchase order number. These records supply the necessary information to pass on to the vendor in cases of rejection in order that the vendor may make a decision on the disposition of the material. If the inspection records are retained over a period of time, a history can be established which is helpful in determining the quality rating of different vendors.

This written record is also desirable because if the inspector is required to put this information on a form which will be picked up and examined by his supervisor, he is less apt to trust his memory as to the sample size, acceptance number, and rejection number. Instead, he will consult the tables for each lot received.

The form used at our plant for recording inspection results is illustrated in Fig. 4. As the inspectors examine the sample quantity, each piece is checked for moisture content, and a frequency distribution is made from the meter readings by placing a dot in the appropriate square on the bottom of the form. All rejects encountered for quality characteristics except moisture content are piled separately. After the first sample is completely inspected, the number of rejects and their causes are recorded. The inspector consults the table to see if the lot is to be accepted or rejected, or if another sample is necessary.

The inspector then determines the moisture range by taking the minimum and maximum meter readings from the frequency distribution and finding the corrected moisture content on the conversion chart for that particular species. The corrected moisture content is written across the form so that it is not necessary to consult the conversion chart each time the forms are examined. A higher AQL is used for moisture content than for other quality characteristics because the limitations on moisture are more difficult for vendors to hold than the limitations on grade, color, etc. If the lot does not meet the desired AQL, the whole lot is tagged for conditioning before being used.

In order for the receiving inspector to function efficiently, definite procedures should be established in the handling of rejects. When veneer is rejected, the cost of 100 per cent inspection is calculated from a standard cost per 1,000 pieces. An estimation is made from the sample inspected as to the total number of rejects in the lot. To the inspection cost is added the cost for reworking and downgrading the rejects. If the total cost does not exceed a predetermined amount agreed upon, the material is inspected 100 per cent with all costs charged back to the vendor.

Since in the majority of cases the total cost of 100 per cent inspection falls below the amount agreed upon, much time is saved because rejected lots are inspected 100 per cent following the statistical inspection, eliminating extra handling and storage and permitting the invoice to be paid on time. When a lot is rejected and the cost of inspection, rework, and downgrading exceed the amount agreed on, the veneer is stored in a separate area, and payment is withheld until the vendor is contacted as to its disposition. The vendor can have the material returned or give his consent for 100 per cent inspection and absorb all labor and material downgrading costs.

Many authorities on statistical inspection agree that information regarding the AQL class being used by a purchaser should be withheld because the vendor might strive to meet the AQL rather than perfection. Our Quality Control Department does not adhere to this theory, for it believes that its vendors are just as eager to meet quality standards as is Brunswick. In addition, it would be difficult for a vendor to agree in advance to pay the labor for 100 per cent inspection if he were not informed as to the percentage of defects which would be allowed.

Veneer received at the plant ranges in size from 12½ by 12½ to 17¾ by 18¼ inches and in lot sizes of 500 to 15,000 or more pieces. During a busy week, 211,000 or more pieces of veneer may be received. By using statistical inspection, one inspector is able to handle this volume, opening the crates; selecting random samples; selecting for moisture content, grade, and size; recording results; and securing the crates after the material is returned.

Since starting statistical inspection on veneer over two years ago, the amount of 100 per cent inspection has been greatly reduced, delaminations resulting from uneven moisture content have been eliminated, and the quantity of veneer being delivered to production which is not according to specifications has been held well below 3 per cent.

Discussion

R. C. Calahan (Singer Manufacturing Co.): Can you suggest examples of applications of acceptance sampling techniques to wood products other than veneer?

Mr. White: Statistical sampling can be applied to any wood product, or any other type product when the following conditions prevail: 1) material is received in lot sizes of at least 500 pieces, 2) a random sample can be picked, and 3) when the value of the material does not justify 100 per cent inspection. Statistical sampling is used for inspecting plywood and several types of hardware at Brunswick, in addition to veneer. It is difficult to pick a random sample from plywood because of its size, and for this reason the sample is usually picked in conjunction with the unloading. Although no dimensional stock is purchased by Brunswick, statistical sampling would be highly applicable to this type of material since it meets all three of the previously mentioned requirements.

Identification of Exterior Plywood[1]

A. H. RAUCH

Product Development Engineer, U. S. Plywood Corp., Seattle, Wash.[2]

A method has been developed for incising ink into veneer which will provide positive identification for exterior plywood in full panels or in pieces down to one square foot in size. By use of a code, certain manufacturing conditions may be included in the marking. Other identification methods are briefly discussed.

IMPROPER APPLICATION of plywood is one of the greatest problems of the plywood industry. Perhaps the most damaging misapplication is the use of interior plywood for exterior exposures. The industry and the Douglas Fir Plywood Association have been aware of this problem since the advent of hot press exterior plywood. One difficulty has been the lack of a foolproof simple means of identification whereby the jobber, wholesaler, retailer, and lay-customer could positively determine by visual inspection whether any panel or piece thereof was exterior or interior type.

The Plywood Research Foundation has been working on this problem for a number of years using several approaches. In the early work, an automatic brander was developed which would edge brand the Douglas Fir Plywood Association required exterior designation every 12 inches along each edge of exterior panels. This machine was designed to automatically feed, brand, and restack 2- by 4-foot to 5- by 12-foot plywood panels of any standard thickness. A light portable hand brander with a calrod heating unit was also developed to assist the industry in turning out legibly marked panels (Fig. 1).

While edge branding is important, there would be an advantage in having a mark extend into the interior of the panel, thus providing identification even though panel edges have been trimmed, or brand mark is miss-

[1] Presented at meeting of FPRS Pacific Northwest Section, Feb 6, 1956, at Longview, Wash.

[2] This study was made while author was wood technologist at Plywood Research Foundation, Tacoma, Wash.

The Author: A. H. Rauch holds B. S. from Oregon State College, was previously employed by Plywood Research Foundation, U. S. Forest Products Laboratory, and Weyerhaeuser Timber Co.

ing or illegible. With this in mind, work was initiated on coloring of the glue line. Harbor Plywood Corporation has been using a green dyed glue line on their brand of marine grade plywood for many years. Since red edge striping is used in the plants to designate exterior plywood, this color was used for most of the glue line identification work. With 1 to 3 per cent emulsified pigment, the glue line of most exterior mixes could be given a distinct reddish cast.

It was found, however, that certain cold press interior glues produced a reddish stain in the veneer adjacent to the glue line similar in shade to the above colored exterior. In order to overcome this problem and make the colored glue line identification system acceptable to the industry, the interior glue line would have to be produced in one color and the exterior in another.

In addition to coloring the glue, the inclusion of small granules or flecks of color in the glue line has been investigated to some extent but has not been found satisfactory to date.

With this background, work was initiated on developing an incising machine and proper inks for marking core veneers. This has been successfully done on a laboratory scale and now awaits trial and application on a mill production basis.

Incisor

The Plywood Research Foundation laboratory incising machine consists essentially of two steel rolls about 5 inches in diameter and 15 inches wide (Fig. 2). The lower driven roll has a single row of incising teeth spiralling for one revolution in the 15 inches of width. The upper roll is adjustable for height and idles against the veneer, forcing it onto the teeth of the lower roll to the depth for which it has been set.

The teeth protrude about 1/4 inch from the face of the roll, and are

Fig. 1.—Hand brander developed by Plywood Research Foundation for efficiently edge branding exterior plywood. Note 110-volt, 350-watt calrod heating unit back of raise-lettered, removable branding slug.

similar to the blade of a small screw driver with a cross slot for picking up ink. They are spaced laterally on the roll about 1/8 inch apart and spiral around the 5-inch roll with a 15-inch lead. This arrangement produces dotted parallel ink mark lines about 45° to the grain direction of the veneer at 11-inch intervals (Fig. 3). The tooth design and spacing for a production machine will depend on the type and amount of ink to be deposited and the mechanical wear experienced.

An ink trough is adjustably mounted below the toothed roll permitting the teeth to pass through the ink at a predetermined depth. A constant depth in the trough is maintained by means of overflow and recirculation of the ink. The incisor has been operated at a lineal speed approximating the operational speed of commercial plywood glue spreaders. This speed was selected to permit installation of the incisor immediately in front of the spreader rolls. With this arrangement veneer fed to the incisor would be passed automatically into the spreader. It would be desirable to mount the machine for quick movement out of the feed area for ease of washing and changeovers in production.

Ink

Available low cost inks, including the type generally used for plywood striping, were tried with the incisor but there was not enough color contrast and penetration laterally for good identification. A water soluble rhodamine type dye was found to have the desired contrast with any of the natural shades of color occurring in Douglas-fir veneer. This dye in water solution produced a satisfactory mark on plywood glued with walnut shell extended exterior mix. It was found, however, that furafil and bark extended glues penetrated the incised marks and masked out the red color. Wetting agents were tried in the water solution to increase penetration but there was not sufficient improvement to overcome the masking effect of the dark glues.

Diacetone alcohol was substituted for water in the above formulation with encouraging results. Side penetration with this ink was about 1/32 inch and in cross section several easily identified marks showed at each incision line (Fig. 4).

It was also discovered that oil-solubilized rhodamine dye could be used with certain oil solvents to give still greater penetration. If a larger mark was desired, this ink could be used rather than the diacetone alcohol type.

Cost of the above inks would be about 25¢ per pound and the rate of application was approximately one pound per 1,000 square feet of veneer. The material cost (25¢ per M) could very likely be lowered with further formulation work, but the cost does not appear to be exorbitant when considering the many overall advantages to the industry.

Identifying with the Incisor

Ink incised veneer gives exterior plywood a permanent positive identi-

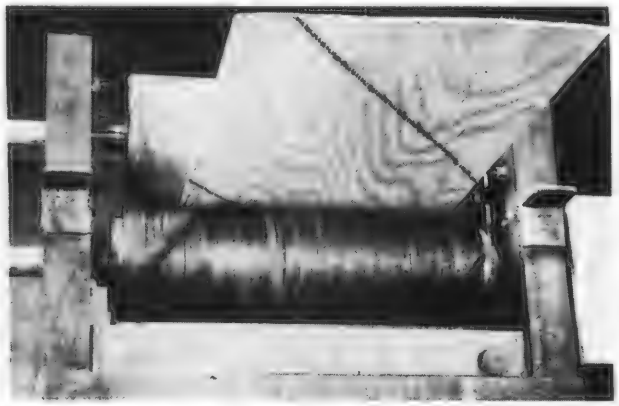

Fig. 2—Laboratory incising machine and under side of marked veneer moving out of incisor.

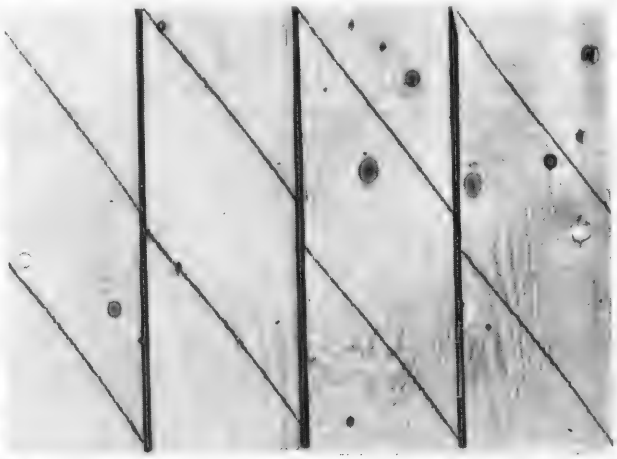

Fig. 3.—Marked Douglas-fir veneers. Diagonal rows of red dotted lines are approximately 11 inches apart.

fication feature. The diagonal dotted red lines in the core veneer leave at least one edge mark on any piece of plywood 12 by 12 inches or larger in size. Since the long dimension of the tooth parallels the grain and the incisions are overlapping in this direction, there will always be a mark when cutting through the design across the grain. However, in cutting parallel to the grain, the mark may be removed should the center line of the saw cut and the incision coincide. By varying the spacing of the dotted parallel mark lines, a smaller or larger minimum marked size may be established.

A few press loads of $\frac{5}{16}$ inch, 4- by 8-foot panels were made in a plywood plant using the laboratory incising machine and the rhodamine-diacetone alcohol ink. All panels had distinct identifiable edge markings. A panel was selected at random and cut into 12- by 12-inch squares to determine marking efficiency. The 32 squares had the core veneer marked as follows: at least one mark per square—100 per cent; at least one mark on each of the end grain edges (cross section)—59½ per cent; at least one mark on either of the side grain edges (radial section)—78 per cent; and at least one mark on each of the side grain edges (radial section)—12½ per cent.

A code system consisting of letters, numbers, other colors or variations in spacing and position of the teeth could be used to signify plant name, date, glue or other manufacturing conditions. Such information would be extremely valuable for improving production control. If frequent changes were to be made, a rapid system of tooth removal and replacement would be necessary.

The incisions are in effect open checks about ¼ inch long parallel to the grain and being in the central ply there should be no appreciable effect on strength properties. Glue-joint test data from specimens in the incision area and immediately adjacent gave no indication of any deleterious effects on the glue line. Results of one of the test series taken from a 4- by 8-foot panel are listed in Table 1.

Summary

Various methods of identifying exterior plywood including edge branding, glue line coloring and ink incising have been explored. Ink incising of core veneer appears to be the most promising method of positively identifying all exterior plywood down to a minimum cut-up size, such as 12 by 12 inches.

A 15-inch wide laboratory incising machine and satisfactory red ink have been developed. They have been used for all the laboratory incising work and for making up several press loads in a plywood plant.

With the incising system described, the edges of exterior plywood panels would show red marks for identification in plant, warehouse, wholesale and retail market. In addition, for the life of the panel at least one red mark would show on the edge of any future cut-up piece down to 12 by 12 inches in size.

With this system, the consumer could be assured that any plywood so marked would be a domestic product of Douglas Fir Plywood Association exterior quality, and an educational program could be carried out based on this positive means of identification. It would also be useful in settling disputes between manufacturers or sellers and consumers. There would be little reason for any misunderstanding as to the type of plywood being used on a job if this marking system were employed by the industry and made known to the consumer.

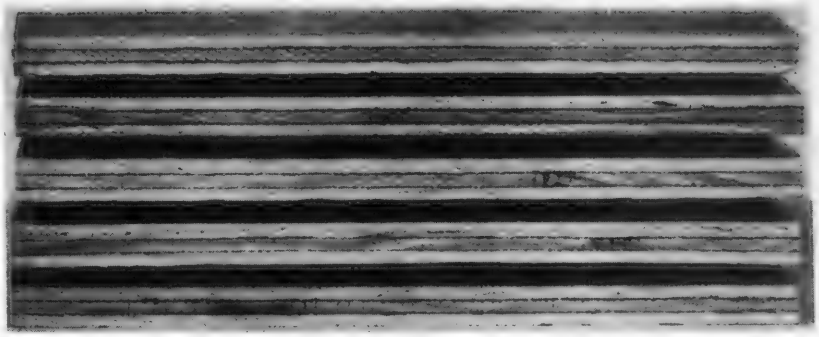

Fig. 4.—Plywood edges, from top to bottom: (1) no veneer marking; (2) marked with rhodamine dye in water solution; (3) marked with rhodamine dye in diacetone alcohol solution; (4) same as (3) except for slight change in ink formulation; (5) marked with rhodamine dye in oil-base formula.

Table 1.—EXTERIOR BOIL* TEST RESULTS

Number	Ink Incised Veneer		Controls	
	Failing Load pounds	W.F. %	Failing Load pounds	W.F. %
1	210	100	200	95
2	250	95	240	95
3	280	65	260	50
4	230	95	250	97
5	170	100	200	90
6	130	100	140	95
7	160	100	130	90
8	180	90	150	90
9	160	100	180	98
10	180	85	160	98
Average	195	93	191	90

*Described in U. S. Commercial Standard CS45-55, paragraph 5.3.2.

Discussion

Q. Are there difficulties with knots under the teeth of the incisor?

A. A cone arrangement is required to remove knots as the teeth rotate. Tooth design is important to minimize knot pickup.

Q. Is it used on Exterior grades only?

A. Yes, so that there is no possibility of using Interior grades. If only Exterior plywood were manufactured the process would be unnecessary.

Q. Will the dye bleed through paint?

A. It did not come near faces but would show on clear-finished edges.

Q. If the laboratory machine was 15 inches wide, what width would be required for production?

A. Probably 28 inches would be necessary.

Q. If the width were fixed, could the process be adapted to different panel sizes?

A. The core feeder could make adjustments by changing the angle.

Q. Was the machine tested on a plugged core?

A. It was not done with plugs. Knots were not a serious problem.

New Approaches to Wood Finishing[1]

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Desirable properties in wood finishes are listed, including decorative and protective features as well as adaptability to modern mass production scheduling. Advantages and disadvantages are reviewed for varnishes, lacquers, low-bake finishes, and decorative melamine resin laminates. Methods of application and properties are described for new approaches such as board surfacing resins and polyester vehicles.

FINISHING OF WOOD may be classed as an art, traceable back into the history of mankind. Modern finishes serve a twofold purpose: decorative and protective.

The average buyer of furniture is probably more concerned with the decorative aspects or the beauty of a finish. To achieve this, the craftsman finisher blends stains to obtain color, color variations, and contrasts. He will also "fill" open-grain woods, and employ sealers and glazes. Finally, a transparent clear topcoating is applied which is either highly polished or dull rubbed. The beholder finds the finish, or furniture, pleasing and appealing.

Later, with the furniture in his home, a buyer will be concerned with the protective qualities of the finish. Doors and drawers will be expected to open and close freely, after years of service. In order to preserve its beauty, clarity, and even its continuity, the finish will have to accommodate both dimensional changes in the film itself and changes in the wood which occur as a result of sudden temperature and humidity variations. Failure to do so results in shrinkage and checking failures. Finally, the finish will be expected to protect the wood against marring and discoloration, and to show resistance to water, alcohol, perfume, cigarette burns, and soiling.

To the furniture maker, the aforementioned decorative and protective requirements of a finish only hint at what may be desired, when considering "How to Select a Better Finish for Furniture". For example, appealing patinas with protective properties could be imparted to wood by a continuing series of oil treatments over a number of years. Obviously, however, such a finish has no place in modern mass production methods. Selecting a better finish also includes the consideration of easy application properties and faster finishing schedules.

If there were a perfect finish, it would have all the desirable properties imaginable. Some of these would be: pale color, fast dry or cure, good film build or depth, good clarity, easy rubbing and polishing — sufficient thermoplasticity, film toughness and mar resistance, good adhesion, good impact resistance, no checking tendencies—including resistance to effects of temperature and humidity, resistance to alcohol, solvents, hot and cold water, foods like citrus juices and salted butter, perspiration, cigarette burns, heat and hot objects; resistance to printing—easy to pack for shipping, economy—low raw material and application costs, easy to apply, easy to patch—including no tendency toward lifting, bland odor in package and in film, package stability.

The perfect finish, of course, is always beyond reach because few people will agree as to what constitutes excellence in the desired properties. The perfect finish is the ultimate and perhaps exists only by definition. The better finish, however, represents a realistic compromise of cost, application, and performance factors.

The American Cyanamid Company is pleased to have taken part in the continuous search for the better finish. Contributions to wood finishing were in the past made in varnish, lacquer, low-bake furniture finish formulations, and decorative melamine resin laminates. Today, a new approach is being pursued with polyester vehicles which cure in presence of air and board surfacing, laminating resins. Before considering the newer approaches in wood finishing, it might be well to review the older methods briefly.

Review of Finishing Materials

Varnishes: Excellent furniture finishes based on oleoresinous varnishes have been and are still being made today. Properties available from these finishes are hard, tough, brilliant films with good polishing and sanding properties and good resistance to heat, water, acids, alkali, and alcohol. For example, alcohol resistance is such that varnish is still a popular finish for bars. Such varnishes are chinawood, short oil (10 to 15 gallons), phenolic, and modified phenolics. For these finishes, various combinations of phenolics and rosin modified dibasic acid resins have been recommended.

While these varnishes may dry within three to four hours, films actually harden through oxidation and polymerization. This delays the sanding and polishing operation for about three days. In addition, initial film color is fair and color stability is poor, since these films tend to yellow badly. Finally, varnish films are rather brittle and may develop poor adhesion and check on aging.

Lacquers: Lacquer is the favorite finish in the furniture industry. This popularity is based on its extremely fast dry, the mechanism of which is solely the evaporation of solvents and diluents from the film. The quick set-out of dust contributes to less dirt pickup and less tendency to sag. The fast dry insures fast handling without marring, little delay in rubbing and polishing operations, and early packing without danger of printing. Lacquer is well adapted for use in the modern assembly line.

Lacquers wear well, having reasonable resistance to dilute alcohol, weak acids, soap, hot or cold water, and hot objects such as dishes. Lacquers are pale in color and have good color stability. In addition, abrasion resistance is rather good. A damaged lacquer finish is readily patched or repaired.

A serious objection to lacquers stems from the fact that they are essentially high viscosity—low solids materials. In order to get sufficient

[1] Presented at Session XII, Wood Finishing, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

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film depth or build to give richness or clarity to the finished wood, more than one coat of lacquer must be applied. And of course this increases the cost of the finishing operation.

There are several ways to effect higher solids in lacquers. The use of a lower viscosity nitrocellulose is limited to 30–35 centipoises by checking tendencies. Higher strength solvents are effective but increase cost. Increased temperature of application or hot spray method have given us lacquers at about 35–38 per cent solids in contrast to the average "cold" lacquer solids of about 25 per cent. The hot spray method, however, due to a number of reasons has not gained wide acceptance in the industry. The approach to higher solids through higher resin ratios is desirable, because it also improves gloss and adhesion of the lacquer and tends to reduce shrinkage. The limitations are poor sanding and printing tendencies.

In the approach to higher solids through higher resin ratios, Rezyl* Resin 50–5 was introduced. This resin is unique in that high percentages may be used with nitrocellulose without impairing drying, rubbing, and sanding properties, or limiting packaging schedules. It eliminates the need for chemical and oil type plasticizers, while imparting permanent flexibility and toughness, even allowing the use of lower viscosity grades of nitrocellulose. A high degree of cold check resistance (over 25 cycles) is not only present in films tested initially, but also after aging two years under various conditions of temperature and humidity. Such formulations are based on Rezyl Resin 50–5, ¼ second nitrocellulose, and rosin modified dibasic acid resin, the latter to improve rubbing and polishing properties. Solids at 22 seconds, No. 4 Ford Cup, will range from 25 to 30 per cent, depending on solvent combinations.

Low-Bake Furniture Finish: This type of finish, now used in great volume in the furniture industry, is generally an alkyd/urea formaldehyde resin combination, plus an acid catalyst or accelerator. It is usually 40–50 per cent in non-volatile solids and may be sprayed at these solid concentrations to smooth films, free of orange peel. In these latter respects, that is high solids and leveling, it resembles varnish. The finish bakes to a hard film in 2 hours at 140° F. or overnight at 125° F. After cooling 30 minutes, it may be then dull rubbed or polished to a full brilliant gloss and immediately packed.

It is advisable in the baking operation to maintain the oven at 30 to 40 per cent relative humidity to avoid excessive moisture changes in the wood and to protect glued joints in the furniture. Another precaution is to allow a short air drying period, 30 minutes, to allow for solvent evaporation and to avoid blistering. These precautions, however, are rather minor and in no way detract from the value of this finish in assembly line production.

The low-bake furniture finishes have excellent film properties. They are fully comparable to the conventional lacquer in marproofness, adhesion, and toughness, and show far better resistance to alcohol, perfume, fingernail polish, grease, solvents, hot water, high humidity, and printing. Many are pale in initial color and excellent in color retention.

The low-bake furniture finish has some minus properties. Because of the insoluble nature of the cured film, they are difficult to patch. In contrast, lacquers are readily patched. While low-bake furniture finishes initially show excellent cold check resistance, passing 25 cycles, after one year of aging they are prone to check. Unfortunately, shrinkage generally occurs after a rather short aging period.

Research in this area led to several recommended formulations, the latest being based on Rezyl* Resin 387–5, Beetle* Resin 216–8, and hard resin. Catalyst 296–9 and cobalt drier, with xylol/butanol as reducing solvent, complete the formulation. This is considered a representative low-bake furniture finish. It passed 25 cold check cycles initially. After aging two years, it exhibited some shrinkage but no checking. Gloss and clarity were restored by repolishing.

Decorative Melamine Resin Laminates: While use of melamine resin laminates may not be considered a method for finishing wood, it does represent a means for finshing flat tops for tables, counters, bars, and walls. The melamine resin laminate provides hard, scratch- and heat-resistant surfaces of exceptional wearing qualities, coupled with excellent color, color stability, and beauty. In this field, pioneering investigations provided melamine resins Cymel* 405 and Cymel* 430.

The melamine resin laminate consists of first a core which is composed of sheets of phenolic resin impregnated kraft papers. The core serves as the backing of the laminate. Next comes the print sheet, which supplies a desired decorative effect by printing on highly pigmented alpha paper. Last or uppermost is the overlay sheet. The printing and overlay sheets are impregnated with melamine from water/alcohol solutions and dried in hot air or infra red ovens. When dried, the print sheet may contain 45–50 per cent resin and the overlay up to 70 per cent. The laminate, generally 1/16 inch thick, is formed by assembling the papers in proper order and pressing between polished cauls for 15 to 30 minutes at 275° F. to 300° F. and 1200 p.s.i.

Taken from the press, the laminate is ready to be trimmed and glued to the desired backing surface to provide a decorative finished panel.

New Approaches

Laminating Board Surfacing Resin: Although this may not be considered strictly wood finishing, attractive panels for furniture construction may be produced with wood grain effect.

Melamine resins require high laminating pressures and therefore cannot be laminated directly to low-density core materials such as wood.

Through research, board surfacing laminating resins have been produced for impregnating overlay grade paper which may be laminated directly to wood surfaces at low pressure. A transparent and colorless finish is produced, having surface characteristics of a high pressure, melamine, decorative laminate, but showing the natural beauty of the wood grain, and not requiring rubbing and polishing. Resin PDL 1–2352, which provides this finish, may be applied over closed grained woods, as well as open grained woods, stained and filled in the conventional manner.

The resin, a modified triazine vehicle, will be marketed at 55 per cent solids in solution of a combination solvent of 2B alcohol and ethyl cellosolve. The overlay paper is treated in conventional paper treating equipment to contain 73 per cent of this resin. When dry, the paper is non-blocking and may be rolled. Although opaque in appearance, this paper becomes transparent when laminated under heat and pressure. Stability or life of the overlay paper when stored under proper conditions is several months. Room temperature of 25° C. and 40 per cent relative humidity are optimum.

Methods for impregnating overlay paper are much similar to those used with melamine laminating resins. Detailed technical information on paper treatment is available for those interested in this phase of the subject. Paper, however, will be available from custom treaters.

The impregnated paper is laminated directly to the wood in a press at 250 p.s.i. at a curing time and tem-

* Trade mark registered in U. S. Patent Office.

* Trade mark registered in U. S. Patent Office.

perature of 10 minutes at 300° F. The laminate assembly may be introduced into a cold press and removed after completion of the laminating process and cooling of the press. This is termed "cold discharge work." The entire process also may be done with the press maintained at 300° F. at all times—"hot-cycle work".

The press plate or caul placed next to the overlay paper is a special type of stainless steel, with a low thermal coefficient of expansion. It is usually chrome plated and may have a mirror-smooth to a sand paper-rough finish. The caul plate imparts the appearance to the finished surface. However, the finish may be easily buffed, if it is necessary to remove minor blemishes or to alter the appearance entirely if it should be desired.

In hot cycle work, the use of highly polished caul plates is not recommended, since uniformity of gloss resulting is poor. Production of satin finish surfaces should be reserved for the hot cycle. In cold discharge work, however, high gloss and gloss uniformity may be obtained and satin type gloss as well if desired.

The caul plates require conditioning with a parting agent to provide for the ready release of the plates from the cured laminate surface. Mitchell–Rand parting agent 1894 EXS has been found to be effective, since the plates remain conditioned for an indefinite number of pressings as long as they are kept free of cured resin particles. Cleaning of the plates when necessary with an alcohol-dampened cloth is helpful.

It should be remembered that this technique for finishing wood represents a one-coat finish application and eliminates the need for rubbing and polishing.

An overlay finish on ¾-inch birch veneer-faced (7 ply) plywood showed outstanding hardness, mar resistance, adhesion, and cold check resistance. Subjected to a light color fastness test (ASTM D620–45T), it showed only a slight visible change, while a representative low bake furniture finish yellowed considerably. It withstood cigarette burning for over 10 minutes, while the low-bake furniture finish failed after 7 minutes.

The laminate also satisfactorily passed the following tests: craze resistance to heat (16 hrs. at 105° C)., and various NEMA tests for resistance to high temperature and resistance to deterioration by such reagents as cold water, boiling water, 2B alcohol, 5% NaOH, 10% citric acid, 5% ammonia, 5% sodium phosphate, 2.5% Tide solution, acetone, and washable ink. The laminate was far superior to the representative low-bake furniture finish in resistance to high temperature, caustic, and acetone.

At present, the overlay finish appears to be limited to flat or working surfaces of furniture (table tops), door panels, and wall panels. However, because of the ease of application of the finish and its outstanding durability, the possibility of its use is excellent for production of pre-finished products at the lumber mill.

The application is not limited to wood finishing. By use of print grade laminating paper impregnated with another board surfacing resin (PDL 1–2247), decorative surfaced hardboards, similar to decorative melamine resin laminates, may be produced. However, the overlay paper containing 73 per cent PDL 1–2352, described previously, together with the print paper, are applied to the hardboard in one operation, without gluing, much in the same way as in the overlay woodfinishing operation. Because only low pressure conditions are required, cheaper low-density particle board and hardboard-faced, low-grade plywood may be suitably decorated.

The print sheet is impregnated to 40 per cent resin content by weight with resin PDL 1–2247. Treatment of the paper and its stability are similar to that described for the overlay with PDL 1–2352 resin.

Polyester Vehicle: One of the latest methods for finishing wood is by use of polyester vehicle Laminac* Resin 4110–4–6. While Laminac Resin 4110–4–6 is much more than a laboratory curiosity, evaluation work is still in progress. This resin is similar to Laminac resins used for the past ten years in the production of glass-reinforced plastics. It has one important modification, however, which permits curing in presence of air at room temperatures to hard, non-thermoplastic, tack-free and sandable finishes. This makes possible its use in furniture finishing.

The polyester alkyd is formed by coreacting an unsaturated dibasic acid and a polyhydric alcohol. Dissolved in styrene monomer, curing takes place by coreaction of the alkyd and the styrene. Physical characteristics of Laminac* Resin 4110–4–6 are:–

Color	1 Max. Gardner Scale
Viscosity at 25° C. G–H	M–O
Acid Number	24–27
Lbs/Gallon	9.30

The resin is almost water white. Stability is good for at least six months, if stored at temperatures below 80° F.

Cure is effected by the addition of an organic peroxide and cobalt naphthenate. The mechanism of cure is unique, since it takes place without loss of any volatile material and without the liberation of water or other by-products. Lacquers, alkyds, and alkyd amino films depend on the rate of diffusion of some substance in or out, for hardness or cure. For example, the lacquer hardens by evaporation of solvent; the alkyd requires diffusion of oxygen into the film; the alkyd/amino combination needs to give up condensation products. These materials thus can cure best in relatively thin films. The self-contained polyester system can cure in coatings from 1½ to 10 mils in thickness. Generally, the thicker the film the better the cure. Thus, only one or two coats are needed in wood finishing, saving time and labor.

Other advantages of Laminac Resin 4110–4–6 over conventional finishing systems are much more chemically resistant films, approaching vinyl resins, with outstanding water and heat resistance. Raw material costs relative to nitrocellulose should also favor the polyester, since effective solids are 100 per cent and in spraying applications only 15–20 per cent of material is lost by evaporation.

Wood Finishing with Laminac Resins

Woods: All types of wood may be finished with polyester. These include open and closed grain wood like mahogany, walnut, fir, pine, birch, maple, etc. However, certain precautions should be observed. Moisture content of the wood should be kept normal to avoid shrinkage. Also, since oily materials are unusually difficult to wet with polyester, areas like knots should be carefully sealed. Finally, Laminac Resin 4110–4–6 has such excellent penetrating properties that in finishing unfilled open grain woods, allowance should be made for resin penetration into end grain to avoid bare spots in the finish. This can be done by an extra pass of the spray gun.

Stains: Water- and spirit-soluble, non-grain raising stains are suitable. These types usually exhibit excellent bleaching resistance. It is best to avoid oil stains.

Sealer or Glaze Coat: Sealers and glaze coats are unnecessary for top notch performance but if they are needed for decorative purposes, the sealer or glaze coat may be the polyester itself. In the laboratory, adhesion between coats of polyester was found to be good. However, this point should be checked in each particular application. Lacquers which do not contain oils or oil-modified resins also are suitable for glaze coats. A satisfactory sealer was prepared from nitrocellulose/dibutyl phthalate/and dewaxed shellac.

* Trade mark registered in U. S. Patent Office.

Fillers: Conventional oil fillers would be compatible if thoroughly dried. Time required (one week), however, would be excessive. Good fillers can be made from polyester and conventional pigments. Additional styrene is added to reach desired viscosity, plus .05 per cent cobalt metal (from 6 per cent cobalt naphthenate material) based on Laminac Resin 4110–4–6 content. A sample of mahogany wood filler formulation for approximately 100 gallons is given:

	Pounds
Laminac Resin 4110–4–6	265
Silica	794
Van Dyke Brown	66
Indian Red	7
6% Cobalt Naphthenate	2.21
Styrene	225

This filler is stable for several months.

The filler may be applied by brush or spray but it must be wiped off immediately, otherwise it becomes too gummy to handle. Filling does not have to be as thorough as with conventional topcoats, because the clear polyester topcoat has considerable filling ability in itself. The filling of smaller areas at a time helps to do a better job.

Sealer: The filler may be topcoated immediately. However, again a glaze coat of lacquer or polyester may be used to obtain color variations.

Build Coats: Build coats are unnecessary in polyester resin finishing.

Finish Coat: A suggested furniture finish based on Laminac Resin 4110–4–6 follows. Yield is approximately 100 gallons.

	Pounds
Laminac Resin 4110–4–6	764
Cab-o-sil	23
Styrene	116
6% Cobalt Naphthenate	6
Add immediately before or during spraying	
Methyl Ethyl Ketone Peroxide	13.5

The amount of catalyst may vary to compensate for temperature differences.

Since the polyester has better flow, wetting, and penetration properties and is applied in much thicker films than alkyds, sagging is a problem. A bodying agent, Cab–o–sil® (a silica flour) in the amount of 3 per cent of the polyester content is advisable. At this concentration, the silica is not visible nor does it have an effect on the clarity of the finish. Cab–o–sil is effective in curbing sagging of films on vertical surfaces 4 to 5 mils thick and also aids in the release of air entrapped in the spraying operation. The silica may be incorporated by pebble milling a few hours in the polyester resin or by intensive mixing.

The styrene is used to adjust to spray viscosity. Best results are obtained at an application viscosity of 40 to 50 seconds No. 4 Ford Cup. Below 40 seconds, the tendency to sag increases; above 50 seconds, atomization is poorer and too much air is trapped. The thinning operation serves also to replace in part the styrene lost by evaporation in spraying.

Cobalt is an accelerator for the peroxide added immediately before application. The optimum and maximum amount of cobalt (as metal and introduced at 6 per cent cobalt naphthenate) is approximately .05 per cent based on the Laminac Resin 4110–4–6 content. Since cobalt is much cheaper than the peroxide catalyst ($1.87 per pound), the tendency will be towards the use of the maximum amount. However, higher concentrations of cobalt should be avoided since they may cause incompatibilities.

A satisfactory catalyst which effects the cure is methyl ethyl ketone peroxide, which is available commercially, 60 per cent in dimethyl phthalate. In combination with .05 per cent cobalt, the peroxide content may be about 1½ per cent of the total formulation. Good safety practice requires that the cobalt solution be thoroughly dispersed in the resin before any addition of the peroxide. In direct contact with each other, cobalt and peroxide react violently.

Pot Life and Cure: After catalyzation, cure of the polyester takes place in two distinct stages. The first stage is the formation of a soft gel, which may require a few minutes or several hours, depending on the concentration of the catalyst used and the temperature. Higher concentration of catalyst and cobalt will give faster set and cure. Every 10° C. rise in temperature up to 95° F. will also double the speed of gelation and cure. Following gelation, curing or hardening takes place rapidly. In a large mass of resin, the exotherm of cure can cause a rapid increase in temperature. In thin films, however, the heat is rapidly dissipated. Cure starts at the resin-substrate interface and travels up through the film. Final result is a dull, hard and sandable surface. Although the finish is dull, it may be buffed to a 60 degrees gloss rating of 90 to 100.

At 77° F., a concentration of .05 per cent cobalt and 3 per cent peroxide could give film gelation in 7 minutes. In spraying, the temperature of the film is cooled so that cure is slower than gelation in the pot. Once the catalyst is added, the mass in the pot could set up hard in as short a time as 4 minutes, again depending on catalyst and temperature. Since the faster the cure, in general the better the resistance and sanding properties of the polyester film, the use of a dual spray system is almost essential for the polyester finish to avoid impractical pot life.

When using a dual head spray gun, the formulation may be divided into two parts, with all the cobalt added to one part and all the catalyst to the other. The cobalt and peroxide thus converge in the air at the moment of application. Since the peroxide will eventually cause gelation, even without cobalt, a catalyst injector spray gun may be preferred. Here one gun sprays the polyester resin plus cobalt, and the other the peroxide (no resin). A 25 per cent peroxide solution for this purpose may be prepared by diluting with styrene and acetone, and bodying with polystyrene for proper consistency. The catalyst is incorporated in desired proportions in the spraying operation.

The use of a dual spray gun system thus eliminates pot life problems and allows fast set. Not only are better film properties obtained from fast set, but delaying the cure too long could result in soft non-sandable surfaces due to excessive evaporation of styrene.

Application Techniques: Polyester finish at 40 to 50 seconds No. 4 Ford Cup is atomized easily with a suction type gun at 40 to 45 p.s.i. pressure. Material should be applied as one heavy pass in order to avoid styrene loss, since poor cure may result from excessive loss of styrene. The spray gun should be held 12 to 18 inches from the object sprayed and trapped air kept down to a minimum. Oily conditions also must be avoided to prevent crawling and similar film defects. While it is possible to brush polyester films and have good flow, this may be a laborious and time-consuming process.

Curing and Finishing: It is mandatory when curing that film temperature remain under 95° F., since above this temperature the polyester does not harden in the presence of air. However, even at room temperatures of 120° F., loss of styrene in spraying may lower temperature of the film sufficiently to enable good cure. There are no blushing problems here, as may be encountered with lacquers.

After film has gelled, it will cure to a dull hard surface which can be sanded in several hours but preferably this should be done after standing overnight at room temperature. To speed up the finishing schedule and to eliminate the odor of catalyst from the film, it may be force dried 15 to 30 minutes at 150° F. just after gelation, and then sanded. As a precaution against gassing, temperatures above 150° F. should be avoided in finishing open grain wood. Slightly higher temperature may be allowable for maple.

Polyester films are easily sanded and polished like lacquers and are less liable to scorch when buffed mechanically. Sanding is done with sandpaper with mineral spirits as a lubricant. The abrasive will dull rapidly since polyester film is hard and non-thermoplastic, but the polyester cuts faster than lacquer. The cuts may be sharper and the sand marks a little harder to remove.

Once sanded, regular furniture compounds may be used with a buffer at speeds which would scorch a lacquer. Films, however, should not be allowed to get too hot in order to avoid gassing in the wood. Sanding and polishing properties may be rated as excellent, and packing may immediately follow these operations. Time period from raw wood to polished article could be less than two hours.

Film Properties and Performance

Polished films of polyester are superior to lacquer in performance properties. They are excellent in appearance, with gloss and clarity far superior to that of the average lacquer and comparable to the best. To only a trained expert would the remotest sign of a haze be discernible. Only a single coat is necessary to achieve build, gloss and clarity, while a lacquer may require two to three coats.

Resistance of polyester film to cigarette burns is outstanding. Films will also withstand hot water for 8 hours or more, depending on film thickness. While the resistance of the film itself to alcohol is also very good, in one half hour of contact, bumps form in the film from swelling of the wood fibers underneath.

Cold check resistance is excellent, films having passed 20 cold check cycles in many tests. In addition, aging properties are superior, since there is no shrinkage of the coating. However, if moisture content of wood is not controlled at the time of finishing, the wood may shrink and give the appearance of having been filled improperly.

Scratch and abrasive resistances are better in polyester than in lacquer. When scratching does occur in the polyester film, however, it is more noticeable. A polyester film would resist to a great extent the blows of a hammer, which in a lacquer would mar the finish and dent the wooden substrate. However, beyond certain limits, severe impact could break and shatter the polyester film.

Polyester film has also been demonstrated as superior to lacquer against discoloration by sunlight. Use of 0.25 per cent of ultra violet absorbers has been found effective in reducing discoloration of wood itself underneath the film.

Films may also be patched satisfactorily before sanding. In one experiment a thickness of 50 mils was built up in multi-coats without any evidence of poor adhesion.

Conclusion

The polyester film fulfills many requirements of the better modern finish, including adaptability to the production line, with fast finishing, packing and shipping schedules, as well as appearance, wearing and resistance properties.

In looking to the future, it is certain that the search for the better finish will continue. Avenues of search will include still newer materials and methods of application, as well as continued interest and progress in the known methods—both old and new—used today.

Acknowledgment

The author wishes to express to John F. Davis, Frank R. Spencer and others, appreciation for their assistance.

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Discussion

P. A. Blachman (The Glidden Co.): When using polyester filler systems on open grained woods, the styrene reducer is obnoxious to use because of odor. Are there any other suitable reducers?

Mr. Kirsch: Styrene is an integral and essential part of the polyester system. Odor problems will be met with adequate ventilation. Acetone could be used as a supplementary reducer.

D. G. Lubeck (Hammond Organ Company): The new polyester system sounds good, but a possible problem arises with fillers. In the past, with new approaches to top coat systems, the filler has often caused the films to fail. A good filler foundation is necessary and until new fillers are developed the benefits of new top coats will be greatly minimized.

Mr. Kirsch: The use of oils in fillers and stains must be avoided. However, conventional pigments may be used with polyesters to yield very satisfactory fillers.

H. L. Bennett (Behr–Manning Corp.): You stated that it is not necessary to rub board surfacing laminating resin. How do you control gloss?

Mr. Kirsch: The surface of the caul placed next to the overlay paper controls the gloss. The caul may be mirror-smooth to sandpaper rough with resultant gloss very high to very low.

D. J. Olmetti (V. J. Dolan & Co., Inc.): Can glazes and lacquer toners be used under catalyzed coatings? Do they have to be the same as the top coat?

Mr. Kirsch: Glaze coats may be used but polyester composition is recommended.

J. T. Geoghegan (E. I. du Pont de Nemours Co.): How do you guard against lack of catalyst in some applications where lines may clog?

Mr. Kirsch: Flow control meters should be watched carefully. Line clogging would be indicated by a reduction of the volume of spray in the dual spray system recommended.

Manufacture of Pure Organic Chemicals From Chemical Pulping Wastes[1]

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The waste liquors from chemical pulping of wood offer a constantly replenished, inexpensive raw material for the production of pure organic chemicals. A number of such chemicals are already in commercial production, several are in pilot plant stage, and many others are still to come.

OUR PRIMARY RAW MATERIAL, wood, comprises roughly 50 per cent of cellulose which exists in the form of fibers cemented together by a material we call lignin. Most of the remainder of the wood closely resembles cellulose, but lacks a fibrous structure. This material is known as hemicellulose. In addition, wood contains varying amounts (depending upon the species) of extractable materials such as resins, fats, tannins, and essential oils.

In the manufacture of chemical pulps, wood is subjected to the action of pulping chemicals in processes designed to produce fibrous cellulose in as pure a condition as practical. Hence, in such processing, the lignin, hemicelluloses, and minor constituents originally present in the wood are largely dissolved and pass into the spent cooking liquors or are carried in small amounts as volatiles with the escaping steam. The spent cooking liquors, wash liquors, and volatile gases, therefore, contain practically all the noncellulosic constituents of the wood employed and are the chemical pulping wastes to be considered in this paper.

Incentives to Utilization

During the past quarter-century, considerable attention has been given to the chemical utilization of the wastes from the chemical pulping industry, and the literature is abundant with suggestions for the recovery of valuable chemical by-products. During the last ten years, the need for conservation in order to meet expanding requirements for raw materials, the urge for more economical production in the face of higher operating costs, and the pressure for abatement of effluents that are regarded as constituting a public nuisance are among several factors that have added new incentives toward a more complete utilization of these pulping wastes. New researches have been initiated in recent years, and outstanding results should be forthcoming in the not-too-distant future.

Waste liquors from the alkali pulping processes, both kraft and soda, produce no pressing problems to the pulp industry, since the economics of the process require that the organic matter be burned for pulping chemical and heat recovery. In the process of recovering B.t.u.'s, the kraft and soda pulp mills within this country consume between two and three million tons of lignin annually. Although this transformation of lignin into heat is an economic method of disposal of the waste liquor as far as the pulping process itself is concerned, it seems like a wasteful manner of treating such potentially valuable chemical raw materials. That the alkaline pulping industry is aware of this is illustrated by the fact that several soda and kraft mills in this country and Canada are already isolating and marketing both softwood and hardwood alkali lignins in commercial quantities. Research on these isolated lignins will lead to new uses for them and to larger scale participation in alkali lignin utilization on the part of the entire alkaline pulping industry.

In the alkaline pulping processes, the noncellulosic carbohydrate portion of the original wood is transformed in large amount to compounds known as saccharinic acids. Recent investigations on saccharinic acids (1)[2] indicate that alkaline pulping liquors are a good source for a saccharinic acid suitable as an intermediate for the production of deoxyribose and nucleic acids, so valuable in diet supplements.

Separation of Tall Oil

In the kraft pulping of resinous woods, the resins in the wood are both saponified and dissolved in the alkaline cooking medium, and occur in the black liquor as sodium soaps. On concentration and cooling, these soaps separate as skimmings which are removed and acidified to yield the so-called tall oil. Tall oil is a mixture of approximately 45 per cent resin acids, 45 per cent fatty acids, and 10 per cent neutral compounds. Before World War II, most mills in the United States, in order to obviate fouling of evaporator tubes, separated the skimmings before final evaporation, and burned them in the recovery furnace to recover heat and soda. During the war, with the supply of much needed fats and oils cut off, the separation of substitute fats and oils from tall oil became an economic necessity. At the end of the war, almost every kraft mill in the United States capable of producing tall oil was collecting its skimmings and making these available to the chemical industry. Separation of tall oil into its chief fractions has been accomplished.

The resin acid fraction is similar in nature to wood rosin, and is indicated for the same uses. This fraction can be separated into individual resin acids or it can be processed to give new chemical materials such as rosin esters, polymeric abietic acid, hydrogenated rosin, and dehydro and tetrahydroabietic acids. The fatty acid fraction comprises chiefly a mixture of unsaturated C_{18} acids which are useful in themselves as drying oils or can be hydrogenated to the well-known stearic acid. New derivatives of stearic and related acids such as chlorides, amides, nitriles, etc., have been placed on the market in the last few years.

The neutral or unsaponifiable portion of tall oil contains various sterols, generally classified as phytosterol. Considerable research is in progress on the possible production of steroids such as certain vitamins and hormones from these closely related sterols of tall oil.

Condensation of the digester relief gases from the kraft pulping of pinewoods yields sulfate turpentine in amounts up to 22 pounds per ton of pulp. Today, sulfate turpentine ac-

[1] Presented at FPRS North-Central Region Meeting Nov. 15–17, 1955, in Chicago, Ill.

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[2] Numbers in parentheses refer to literature cited.

counts for a high percentage of the total turpentine production of the United States. Chemically, sulfate turpentine resembles wood turpentine. Thus, the kraft pulp industry has in its tall oil and sulfate turpentine the raw materials for a by-product resin and terpene chemical industry similar to that which has evolved in the wood and naval stores industry.

Developments in Kraft Industry

A new development in the kraft pulping by-product industry is the commercial production of dimethyl sulfide as a pure organic intermediate by a west coast kraft pulp mill (2).

The acid or sulfite pulping process, as usually employed with calcium base, is more wasteful than the alkaline processes in that it does not require heat and chemical recovery from its waste liquor for economical operation. The necessity for getting rid of large volumes of spent sulfite liquor daily has been a constant and costly headache to the sulfite pulp industry and, as a consequence, large sums of money have been spent for many years on research. Several processes of importance have been developed in the course of this research.

The pollution problem has been overcome at a few mills by changing to magnesium base (3). Magnesium-base spent liquors, unlike calcium-base liquors, upon evaporation and burning, yield sulfur dioxide and base ready for re-use. Ammonia-base liquors have been adopted by some mills who evaporate and burn without chemical recovery (4). In all of these cases the potential value of the noncellulosic organic material originally present in the wood is utilized only as fuel.

The chief organic components of spent sulfite liquor are sugar and lignin. The sugars of spent sulfite liquor, comprising both pentoses and hexoses, are amenable to many types of fermentations including alcohol, lactic acid, butanol, acetone, acetic acid, etc. In addition, they can be hydrogenated to glycerin. Unfortunately, under normal conditions in the United States, these sugars must compete with other cheap and plentiful sources of carbohydrates such as black strap molasses and grains and, in the case of alcohol or glycerin production, with cheap by-product petroleum gases. The sugar content of softwood spent sulfite liquors can be utilized to a large extent by alcoholic fermentation, and one mill in the United States is now producing sulfite alcohol in a plant built during the war and is competing in the present market (5). Approximately 95 per cent of the sugar content of either hardwood or softwood spent sulfite liquors can be utilized in the production of *Torula* yeasts. Two mills in Wisconsin are now producing *Torula* yeasts commercially (6). These products are finding uses in animal feedstuffs and as food supplements for both human and animal use.

Uses for Lignin

The above noted utilizations of the sugar component of spent sulfite liquor still leave the lignin component as a waste product. At present, millions of tons of this waste lignin are discharged into the streams and waterways of this country. In this waste lignin we have a raw material that potentially can rival coal tar or petroleum as a source of synthetic organic chemicals. To salvage this potentially valuable chemical raw material, we should know more about it. A great deal of research has been done in the field, but much more remains to be done. Many hundreds of patents have been granted on the utilization of the lignin in spent sulfite liquor, but few have been found economically feasible in the past.

The conversion of sulfite lignin into pure organic chemicals of low molecular weight offers one of the largest fields for research and development. In 1937 the commercial production of vanillin from spent sulfite liquor in low yield was initiated in both the United States and Canada, and before long the American plant was supplying about two-fifths of this country's vanillin requirements. It is interesting to note that even in the low vanillin yield obtained, the waste lignin available to this one American plant was sufficient to meet the present vanillin requirements of the entire world. Continued research on the part of lignin vanillin producers and chemists resulted in increased yields and lower production costs so that today essentially all of the vanillin used in this country is produced from the lignin of spent sulfite liquor. Two mills in this country and two mills in Canada now produce vanillin from spent liquor (7). Unfortunately, flavoring vanillin requirements are so small that the amount of spent sulfite liquor utilized in this manner represents only a fraction of 1 per cent of the available spent liquor.

Realizing that a study of the chemistry of vanillin and its derivatives, with the subsequent development of new chemical uses for vanillin, would stimulate chemical industry and result in the wider utilization of waste lignin, such a project was initiated a number of years ago in the author's laboratory at The Institute of Paper Chemistry. This fundamental research program was sponsored by the Sulphite Pulp Manufacturers' Research League.

Processes were found for the simple conversion of vanillin to its derived acid, vanillic acid, which heretofore had been a laboratory curiosity (8). In addition, the oxidation of lignin directly to vanillic acid was achieved in relatively high yields. Many new esters and derivatives of vanillic acid have been prepared and tested for various uses. For example, ethyl vanillate was found to be less toxic than sodium benzoate toward humans, but very toxic to specific micro-organisms. As such it found uses as a preservative in foodstuffs and in the treatment of human diseases. At present it is manufactured commercially for the specific treatment of the progressive disseminated form of the two mycotic diseases, histoplasmosis and coccidioidomycosis (9). The ultraviolet absorption characteristics of ethyl vanillate make it useful in sunburn preventatives and its antimycotic properties indicate its use for topical treatment of skin fungus infections (8).

Vanillin has been converted into hundreds of related compounds and many of these have been evaluated for a variety of end uses. It is expected that some will soon be in commercial production. In addition to vanillin and vanillic acid, other possible organic chemicals which can be prepared from spent sulfite liquor lignin are guaiacol, acetovanillone, syringaldehyde, syringic acid, 5-carboxyvanillin, 5-carboxyvanillic acid, vanillil, and a host of other guaiacyl and syringyl compounds (10). However, all of these products represent only a fraction of the lignin complex. The complete chemical utilization of lignin will be obtained only after a process is evolved for the degradation of the entire lignin complex to usable guaiacyl or syringyl compounds of low molecular weight. To this end, lignin chemists everywhere are applying themselves.

Other By-Products

Spruce turpentine, the condensate from the relief gases obtained during the sulfite digestion of coniferous woods, is essentially *p*-cymene with small amounts of dipentene, borneol, and sesquiterpenes. *p*-Cymene has been converted on a commercial scale to such aromatic compounds as cumic acid, dimethyltolylcarbinol, methylacetophenone, and methylstyrene.

Another by-product of the sulfite pulping industry which has recently attracted considerable interest is conidendrin, a compound isolated from spent sulfite liquor over 60 years ago and called "sulfite liquor lactone."

This compound can be isolated in relatively pure state by treatment of western hemlock sulfite spent liquors with water-immiscible organic solvents. Although present in only low concentration in the spent liquor, the average Pacific northwest sulfite mill could isolate easily several tons daily of this potentially valuable fine organic compound (11). At present a pilot plant operation of one mill is supplying enough conidendrin for market studies, and it is hoped that commercial production will begin in the near future (12). Demethylation of conidendrin yields a very potent anti-oxidant for fats, oils and other materials. Many derived products have been prepared from conidendrin, and the utilization of these products is also being studied (13).

The fullest utilization of the waste liquors from the chemical pulping of wood for the production of organic chemicals is in line with the increased necessity of conserving our dwindling supply of remaining natural resources. Wherever possible, we should employ raw materials which are constantly being replenished by nature, rather than those slowly accumulated over geologic ages. To this end, wood and its waste products should gradually replace coal and petroleum as a source of many of our organic chemicals.

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Motion Energy of Wood Particles

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Analyzes energy expended in removing sawdust, shavings, or chips in sawing and planing operations. Several applications of motion energy studies are pointed out, such as their importance in selecting motor size and operating speed, designing improved saws, and solving problems encountered with thin saws which will result in savings in both power and wood.

TO THE SAWYER, when he can see it, the stream of sawdust pouring from a fast-cutting saw is a pleasing sight. To the mill manager, it is a symbol of "production," the modern fetish. To the treasurer, who doesn't see it, it is one of those necessary costs lumped in with others under "Milling Costs."

Actually, outside of the obvious cost of the raw material that is converted to sawdust and the cost of its disposal, sawdust makes another drain on the treasury that isn't generally recognized. It is the cost of speed.

Speed in a sawblade is essential, but velocities above 200 feet per minute are justified only by advantages that are not related to the action of the cutting edge, such as high production rates, better surface quality, and stability of the saw. The power requirements per unit of sawed area are practically constant for velocities above 200 feet per minute, so far as the actual cutting is concerned. It is in the removal of the sawdust, however, that speed affects the power requirements.

A few particles of sawdust, or even a handful, weigh so little that the weight is readily ignored. But a good 13 per cent, or better than one-eighth of a log, is ordinarily converted into sawdust, which means that the equivalent of 1 out of every 8 logs has to be hurled from and by the saw at the rim speed or tooth velocity at which it is cutting. With tooth velocities or rim speeds in the neighborhood of 8,000 feet per minute, it is not difficult to realize that an appreciable amount of energy would be required to bring every eighth log up to this speed.

It is of no consequence, as far as total energy is concerned, whether or not the energy is applied to a single large mass or to a multitude of small masses of equal total weight. Thus, each sawtooth removes a small mass of wood from a log which has negligible velocity, and chambers it in the gullet. Since the gullet is moving at saw speed, the sawdust it contains must be brought up to that velocity. The energy thus expended through the saw gullets to mobilize each and every small lot of sawdust removed in sawing a 16-foot log adds up to the same amount that is required to give the same velocity to a 2-foot chunk from that log. Frictional energy in churning in the gullet and in rubbing against the kerf walls is a separate problem and is not involved in this analysis.

Determining Motion Energy

The total motion energy required can be determined readily if several factors are known. One is rim speed or saw velocity. Another is the width of the kerf. The third essential is the unit weight of the material in the condition in which it is being cut (Table 1 presents green weights for a number of United States species).

The energy per unit area of sawed surface can be obtained from these three factors. If cutting depth and feed rate are included, the horsepower used for sawdust movement can be determined, and if the surface area sawed per hour is known, the total energy in horsepower hours or kilowatt hours can be computed.

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Author: L. H. Reineke joined U. S. Forest Service in 1923 as junior forester, received B.S. in forestry from Cornell U. in 1929. After year of graduate study at U. of California, he joined Northeastern Forest Experiment Station. Reineke came to the Laboratory in 1942, has since worked on woodworking machinery and methods research. In 1950 he developed first duokerf saw, a rip saw which cuts and planes wood at same time.

The basic formula for kinetic energy is:

$$E_K = \frac{w.v^2}{2g}$$

where E_K is the kinetic energy in foot-pounds of an object weighing w pounds and moving at a velocity of v feet per second. The gravitational constant g is 32.2. By substituting numerical values for w and v, the energy in foot-pounds can be computed under various conditions and expressed in various ways.

For example, a pony band rig in a West Coast mill cutting Douglas-fir has a band speed of 9,000 feet per minute and cuts a kerf of 0.200 inch. The average weight of green Douglas-fir (coast-type) is 39 pounds per cubic foot.[2] For each square foot of area sawed, the sawdust volume is $0.200 \div 12 = 0.0167$ cubic foot, weighing $0.0167 \times 39 = 0.65$ pound. Since the saw velocity is $9000 \div 60 = 150$ feet per second,

$$E_K = \frac{0.65 \times (150)^2}{2 \times 32.2} = \frac{0.65 \times 22{,}500}{64.4}$$

$= 227$ foot-pounds per square foot of sawed surface.

For each thousand feet of 1-inch lumber sawed, some 227,000 foot-pounds of energy must be used merely to make the sawdust fly. In terms of horsepower, this amounts to $227{,}000 \div (33{,}000 \times 60) = 0.115$ horsepower-hour or $0.115 \times 0.746 = 0.0855$ kilowatt-hour.

Additional power also will be consumed to make the shavings fly if this lumber is dried and planed. The energy required will be less than in the sawing, however, since the dried lumber is lighter, and the total planing allowance is less, making the weight of the shavings from both sides of 1 square foot of lumber somewhat less than the weight of the green sawdust.

If lumber with an air-dry weight of 34 pounds per cubic foot is dressed off a total of $\frac{1}{8}$ inch at a cutterhead-rim speed of 10,000 feet per minute, the motion energy in shavings produced in dressing 1 square foot of lumber is 153 foot-pounds per square foot of lumber, surfaced 2 sides (S2S). This is 67.5 per cent as much motion energy as required for green sawdust. On a per 1,000 foot board measure (MBM) basis (1-inch material), the total power represented in the motion of the sawdust and shavings would be 0.1926 horsepower-hour or 0.143 kilowatt-hour.

The power consumed may seem like a small item in the cost of surfacing 1,000 square feet of S2S lumber, even when the absorbed power is divided by the efficiency ratio of the machinery involved to get the power input. Assuming an efficiency of 0.90 from power source to saw teeth or knife edges, the saw motor would account for $0.115 \div 0.9 = 0.128$ horsepower-hour and the planer drive from $0.078 \div 0.9 = 0.083$ horsepower-hour when the production rate was 1 MBM 1-inch material per hour.

For other production rates, of course, the power would vary directly with the rate. The computation required is merely one of multiplying the power per square foot by the production per hour or day, with a factor for converting board measure to surface footage. If a Douglas-fir mill, for example, is cutting 50 MBM per 8-hour day and averaging 30 M 1-inch, 15 M $1\frac{1}{4}$-inch, and 5 M 2-inch stock, the surface footage would be

$$\frac{30}{1} + \frac{15}{1\frac{1}{4}} + \frac{5}{2} = 44.5 \text{ M square feet,}$$

and the converting factor would be $\frac{44.5}{50}$ or 0.89. The sawdust energy, then is

$$hp._{(sawdust)} = \frac{227 \times \frac{50{,}000}{8} \times 0.89}{33{,}000 \times 60}$$

$= 0.638$ hp.-hr. (0.476 kw.-hr.)

and the shavings energy is

$$hp._{(shavings)} = \frac{157 \times \frac{50{,}000}{8} \times 0.89}{33{,}000 \times 60}$$

$= 0.430$ hp.-hr. (0.321 kw.-hr.)

Thus, a total of 1.068 horsepower-hours or 0.797 kilowatt-hour is the energy per hour (unadjusted for efficiency) imparted to the sawdust and shavings.

The hourly or daily cost of power converted to motion of sawdust and shavings is readily obtainable from the foregoing figures, but the full extent of the effect of such motion is not disclosed. The machinery used must be powered for the maximum, not the average demand, so that instantaneous sawing and planing rates must be considered.

The feed mechanism of the planer provides a lineal feed rate that ordinarily remains constant for any one run of stock, but the feed rate may be changed from lot to lot. Although feed rate may be constant, power demands vary with width of stock being surfaced, depth of cut, density of the wood, and number of surfaces being planed at one pass. In sawing, the number of cutting surfaces and the kerf width remain constant while wood density remains as a factor. However, the feed rate and face width are variable between wide limits.

The rate of sawing is, of course, a composite of the depth of cut and the lineal feed rate, with the product giving area sawed per unit of time. Since feed rate tends to diminish as depth of cut increases, the area sawed per minute varies less than cutting depth or feed speed.

With modern high-speed sawing, however, the time for one cut gives the average speed, but it does not give the maximum for the cut. With fast setting devices and snappy carriage drives, the sawyer can stop his gigback within a foot of the saw, which means that the log will meet the saw at a low speed. Acceleration of the carriage during the cut and deceleration to avoid overshoot at the end of the cut result in a varying sawing rate. The peak feed rate determines how much power is taken from the saw to give saw velocity to the sawdust.

At the West Coast mill used as an example, the maximum average sawing rate was 200 square feet per minute, whether cutting a 4-inch depth at 600 feet per minute or a 19-inch depth at 125 feet per minute. At this average rate, the peak rate was about 40 per cent higher, or 280 square feet per minute.

Applying this rate to the energy per square foot determined by the basic formula, 280×227 foot-pounds $= 63{,}560$ foot-pounds per minute or a total of 1.92 horsepower of the saw's total power merely to impart velocity to the sawdust.

Similarly, in planing with a double surfacer having a 30-inch opening and feeding 150 feet per minute, the maximum footage will be $\frac{30}{12} \times 150 =$ 425 square feet per minute. Applying this to the energy per square foot previously determined, the total energy is $425 \times 153 = 65{,}025$ foot-pounds per minute, 1.97 horsepower. This value could be increased by half or more if the excess thickness of inaccurately sawed rough lumber were $\frac{1}{16}$ inch or greater. Approximately 1 horsepower additional would be required for each $\frac{1}{16}$ inch of excess thickness.

It is obvious that the energy in sawdust and shavings will increase in direct proportion to the weight of the wood. For green hardwoods, such as hickory (64 pounds), red oak (63 pounds), and sugar maple (56 pounds per cubic foot), energies will be 50 to 75 per cent more than those for Douglas-fir under the same sawing conditions.

It is less obvious, however, that an increase in sawtooth or cutter speed will produce a disproportionate increase in energy. Since the velocity

[2] See Table 49 of Wood Handbook, U. S. Department of Agriculture Handbook No. 72, 1955. Weights of green wood may vary because of differences in density and moisture content.

factor is squared in the basic formula, a doubling of cutting-edge speed will quadruple the motion energy of the chips. The following table illustrates the effect of cutting-edge velocity for a 60-pound wood being sawed with ¼-inch kerf at a maximum rate of 250 square feet per minute.

Rim speed Ft. per min.	Power required for sawdust motion Horsepower
2,500	0.255
5,000	1.02
10,000	4.08
15,000	9.18
20,000	16.32

At cutting-edge velocities of 10,000 feet per minute or less, the power put into sawdust motion is not important. In some tests on hickory at the U.S. Forest Products Laboratory, the motion energy at 9,000 feet per minute was 1.5 per cent of the total sawing energy. However, if saw-rim speeds are increased—and some Russian mills are reported to be operating with rim speeds as high as 20,000 feet per minute—the power required merely to bring the sawdust up to rim speed becomes important from the standpoint of motor size.

The effect on driving motor size becomes particularly important when dealing with chipping operations. Here, the entire amount of wood being processed, not merely the kerf or dressed-off portion, has to be brought up to high velocity. In the cylinder type of chipper or knife hog, chip velocity equals the surface speed of the cylinder. In the disk type of chipper, motion of the chips differs in two respects.

First, the cutting edges are arranged more or less radially, so that the velocity varies with the distance from the center of rotation. Since motion energy varies with the square of the velocity, the energy in chip motion will vary as the square of the radius of each point on the cutting edge. Since the dimensions of logs or other material fed to the chipper vary widely, the calculation of energy must consider the frequency distribution of sizes.

The second difference of the disk chipper is the passage of chips through the disk, which affects their movement. When the chips are ejected from the disk, the direction of chip movement is the resultant of a tangential movement due to centrifugal force, an axial movement due to knife bevel, and a radial movement due to the "drawing" action of the knife when it is not positioned radially in the disk. Since the combined effect is movement in a direction quite different from that of the cutting edge, the chips may clear the cutter at considerably less velocity than that of the cutting edge.

Computation of the velocity under these conditions would be rather involved and further complicated by the different range of cutting-edge velocity for different sizes of material. Photographic measurements of chip movement might be more reliable and informative than the direct calculations. Still cameras with exposures long enough to produce measurable blur for speed calculation could be used as well as high speed movies. Rapidly repeated flashes (stroboscopic illumination) also could be used. True velocity and true direction of movement could be ascertained by using two cameras at right angles—one vertically above and the other horizontally opposite the position to be photographed. By using the open-shutter technique, each flash will be recorded by both cameras. Chip velocities and directions shown by each pair of photos can be resolved to give the true direction and velocity.

Table 1.—GREEN WEIGHTS OF COMMON WOODS OF THE UNITED STATES*

Hardwoods		Softwoods	
Species	Weight Lb. per cu. ft.	Species	Weight Lb. per cu. ft.
Alder, red	46	Baldcypress	51
Ash, white	48	Cedar, incense	45
Aspen	43	Port-Orford-	36
Basswood	42	western red	27
Beech	54	Douglas-fir (coast-type)	38
Birch, yellow	57	Fir, white	47
Elm	54	balsam	45
Hickory	64	Hemlock, western	41
Ironwood, black	86	Pine, southern	52–58
Locust, black	58	northern white	36
Magnolia	49	ponderosa	45
Maple, sugar	56	sugar	52
Oak, red	63	Redwood (virgin)	50
white	62	Spruce, red	34
Poplar, yellow	38	Sitka	33
Sweet gum	50		
Sycamore	52		
Tupelo, black	45		
water	56		
Walnut, black	58		

*Adapted from Table 1 of U. S. Department of Agriculture Technical Bulletin No. 479, "Strength and Related Properties of Woods Grown in the United States." This table should be consulted for individual species weights or weights of additional species.

Applications

Flying wood particles of sawdust, shavings, or chips have been considered as absorbers of energy. The quantities of energy involved may be inconsequential in relation to the process, but they may be important enough to require consideration in selecting motor size and operating speed.

There are other applications of this analysis of motion energy. In pneumatic conveyors, motion energy could be conserved if the particles could enter the conveying system without loss of velocity. In the design of control devices, even the small amounts of motion energy involved with small, thin saws may merit calculation in designing control devices actuated by the impact of wood particles. Such a device for controlling feed rate could be actuated by the impact of sawdust or shavings against a pivoted spoon or vane.

Calculations of motion energy also have application in research in the cutting of wood. In studying the effect of speed on the cutting action, power measurements should be corrected for the motion energy imparted to the particles. In any analysis of the division of energy between the several phases of cutting (fiber severance, fiber shearing, crumbling, friction), motion energy must be accounted for if the distribution is to be correct.

Isolation and determination of the magnitude of individual forces making up the total sawing force is an important step. Knowledge of these individual forces is necessary in designing improved saws. This may also lead to the solution of present problems encountered with thin saws and result in savings of both power and wood.

Distribution of Fungicidal Extractives (Thujaplicin and Water-soluble Phenols) in Western Red Cedar Heartwood[1]

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Analyses for natural preservative content by chemical methods established a general pattern of increasing content with increasing radial distance from the pith and decreasing content with increasing distance up the tree. Where typical color variations occurred within a sample, a change from a lighter to a darker color coincided with a reduction in natural preservative content. Hot water solubilities of up to 23 per cent and thujaplicin contents up to 1.2 per cent were found.

Introduction

THE HEARTWOOD OF WESTERN RED CEDAR *(Thuja plicata* D. Don.) has a well-established high resistance to decay, even under conditions favorable to wood-destroying fungi. Thus it has been widely used as fence posts, telephone poles, shingles, sidewall shakes, and siding for many years. Although its durability is one of the most interesting and useful properties of cedar, little information on the variations to be expected in this important property of a natural product has been available heretofore.

Sowder (16) in 1929 showed that substances toxic to fungi could be extracted from western red cedar with water. Cartwright (4) in 1941, working with samples taken from a 65-year-old Scottish-grown western red cedar tree, found that decay resistance varied with position in the tree and appeared to be closely correlated with similar variations in the content of hot water solubles.– Water solubility and decay resistance increased radially with distance from the pith and decreased with distance up the tree from the butt. In general his results agreed with those obtained previously for redwood *(Sequoia sempervirens)* by Sherrard and Kurth (15).

The heartwood of western red cedar exhibits wide variations in color when fresh-cut, ranging from a light straw color (frequently present in a wide outer band in the butt of mature trees and not to be confused with the narrow band of almost white sapwood) through pale reddish brown to a chocolate brown. These colorations may be present in large concentric zones or in streaks of small cross-section. Some typical variations in color are illustrated in Fig. 1.

An investigation into the cause of dark brown surface stains occurring erratically on striated sidewall shingles undertaken in this laboratory in 1951 disclosed that the water-soluble extractives were responsible and that the troublesome straining was most prevalent on straw colored heartwood. In the course of this work, the hot water solubility of different color zones adjacent to one another in seven shingles was determined by the standard TAPPI method. The analytical samples were chosen on the basis of color only and without regard to distance from the pith. Estimates of the colors by the Munsell system of classification (11) were made for samples 1 to 5. Sample 6a consisted of a single growth ring carefully excised from the shingle and compared with the lighter brown growth ring (sample 6b) next to it.

The results given in Table 1 indicated that the hot water solubility of

[1] Presented at meeting of FPRS Pacific Northwest Section, May 7–8, 1956, in Eugene, Ore.
[2] W. D. S. Bowering assisted in the analytical work

Fig. 1.—Color variations in three western red cedar heartwood shingles described in Table 8 and Fig. 5.

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cedar was subject to wide variations since in this limited sampling it ranged from the low figure of 2.6 per cent to a high one of 15.75 per cent; also in each sample a change of color from light to dark coincided with a decrease in hot water solubility. This change of water solubility with color change within a sample, together with the correlation between solubility and decay resistance found by Cartwright, suggested that the content of natural preservatives in cedar wood might also change with color.

It has been known for many years that water extraction of western red cedar removes its natural decay resistance (16). In fact, cedar sawdust extracted with hot water is used in laboratory decay studies as a substrate to support fungal growth. Two groups of water-soluble chemical compounds with fungicidal properties have been isolated from western red cedar, the thujaplicins and the water-soluble phenols. The thujaplicins α, β, and γ -isopropyltropolone (3, 4, and 5-isopropyl, 2-hydroxy-2, 4, 6-cycloheptatriene-1-one) isolated and identified by Erdtman, Anderson and Gripenberg (1, 8) and independently from another species by Nozoe (12), have a fungicidal activity of the order of pentachlorophenol (13). The water-soluble phenols isolated in this laboratory during the course of a chemical examination of the cedar extractive (3) are much less toxic to wood destroying fungi, being of the order of zinc chloride (14).

In the chemical investigation of the cedar extractive, wide variations were noted in the yields of the toxic components, the thujaplicins and the water-soluble phenols. These observations, in conjunction with those made previously on the variation or hot water solubility with color and the data of Cartwright on variation of hot water solubility and decay resistance with position, led to a study of the distribution of these chemicals in relation to both color and position. Establishment of the natural pattern of variation was of considerable practical importance in view of the potential usefulness of these chemicals and the obvious connection between their distribution and variations in the natural durability of the wood.

Methods of Analysis

The first objective was to develop analytical methods which could be applied routinely to wood samples for content of thujaplicin and water-soluble phenols.

An accurate method for the thujaplicins was devised based on colorimetric estimation in an aqueous extract of the wood. The method is described in detail elsewhere (9).

Table 1.—SOME HOT WATER SOLUBILITIES OF CEDAR WOOD IN ADJACENT COLOR ZONES

Shingle No.	Color Zone: Trivial	Color Zone: Munsell* Classification	Hot Water solubility (% of moisture free material)
1	(a) Light brown	5.0 YR 6.8/6	10.6
	(b) Straw	9.0 YR 7.3/4.5	12.8
2	(a) Brown	7.0 YR 3.9/3.5	10.8
	(b) Straw	7.5 YR 8/5.5	13.9
3	(a) Choc. brown	5.0 YR 3.8/4	2.6
	(b) Straw	9.0 YR 7.3/4.5	6.8
4	(a) Brown	5.0 YR 5/4.5	10.4
	(b) Straw	7.5 YR 8/5.5	12.4
5	(a) Pinkish brown	10 R 4.8/6	15.0
	(b) Straw	10 YR 8/6.5	15.8
6	(a) Dark brown	----------	7.0
	(b) Light brown	----------	9.4
7	(a) Brown	----------	11.9
	(b) Straw	----------	13.6

*Numerical color classification is from the Munsell Book of Color (11).

Use of a primary extraction with hot water allowed a simultaneous determination of hot water solubility. To insure quantitative removal of the thujaplicins, the aqueous extraction method adopted differed in detail from the standard TAPPI method, being more rigorous. A 2 gm. 40 mesh sawdust sample of known moisture content is extracted first with 100 ml. of water at 100° C. for 1 hr. After decanting the extract through a tared filter crucible, the extraction is repeated with 50 ml. and then 25 ml., after which the residual sawdust is washed with a further 25 ml. of hot water, dried, and weighed. The extracts and washings are combined for the thujaplicin analysis.

The known complexity of the water-soluble phenols provided little hope of developing a routine precise method of analysis for this fraction of the extractive. However, since preliminary chemical examinations had provided evidence that the polyphenols were derivatives of pyrocatechol and furthermore that pyrocatechol groups accounted for the content of phenolic hydroxyls, it was reasoned that a method of determining such groupings might provide an approximate index of the polyphenol content.

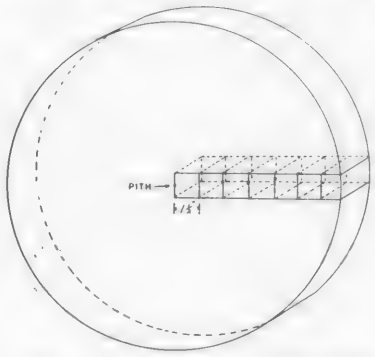

Fig. 2.—Method of sampling heartwood cross-sections for determination of radial distribution of extractives.

A method based on lead precipitation of pyrocatechols using either gravimetric or volumetric assay of the lead consumed appeared promising at first but was rejected because of poor reproduceability. Finally the A.O.A.C. method (2) for "tannins" in tea was adopted. Williams (17) has shown recently that this titration of tea polyphenols with standard potassium permanganate solution using indigo carmine as an indicator is, in effect, an estimation of pyrocatechol groups.

Tests of the method with the cedar polyphenols and aqueous cedar extracts indicated that no complicating factors were present. Accordingly, determination of the content of water-soluble phenols was simply a matter of titrating aliquots of the aqueous extracts with permanganate, using indigo carmine as an indicator. To provide a basis of comparison, the results are calculated and reported in terms of the isolated water-soluble phenols examined for toxicity by Roff and Atkinson (14) and which in test consumed 400 ml. of .0446 N potassium permanganate per gram.

For determination of the radial distribution of the extractives, a radial slice about $\frac{3}{4}$ inch wide was cut from a cross-section about 2 inches thick. This slice was then cut at $1\frac{1}{2}$ inch intervals from the pith to the periphery of the heartwood as indicated in Fig. 2. The resulting blocks, approximately $\frac{3}{4} \times 1\frac{1}{2} \times 2$ inches, when converted to sawdust in a Wiley mill provided ample material for moisture determinations and duplicate analyses of hot water solubility, thujaplicin, and water-soluble phenols content. Similar analyses of cross-sections obtained at different levels within one tree provided data on the vertical distribution of the extractives.

Results

In all, cross-sections of eight trees ranging in age from 20 years to 750 years were analyzed. To provide some additional data on variation of the extractive content with color, three fresh-cut shingles exhibiting several color zones were also analyzed.

Tree No. 1: The sample consisted of a single cross-section obtained at a local shingle mill from the butt log of a sound 650-year old, 38-inch diameter tree of even growth rate cut in the Hibbard Lake area near Seymour Inlet, B. C. The color of the fresh-cut heartwood changed from a medium brown near the pith to a straw color in the outer heartwood, through a pinkish brown transition zone at 6 to 7½ inches from the pith. In the straw colored heartwood at 12 to 13½ inches from the pith in the same cross-section but displaced tangentially from the sample slice about 90°, there was a small isolated pocket of brown wood with pinkish brown borders. This brown wood was also sampled to allow a comparison with straw colored wood equidistant from the pith in the main sampling quadrant.

The results are given in Table 2 and graphed in Fig. 3. No figures for content of water-soluble phenols are reported since at this stage of the work a suitable method for their determination was not available. The pH of the aqueous extract was recorded for each sample.

The nineteen-fold radial increase in hot water solubility from the low figure of 1.2 per cent near the pith to the high figure of 22.8 per cent in the short distance of 13½ inches indicates a radical difference in toxic extractive content between the inner and outer heartwood of this mature western red cedar. The thujaplicin figures are also interesting since they show that although the content of the wood around the pith is practically zero, a large portion of the total volume of the cross-section contains more than 1 per cent of this potent natural fungicide.

Table 2.—ANALYSES OF BUTT CROSS-SECTION FROM TREE NO. 1
(percentages are based on moisture-free wood)

Distance from Pith (inches)	Color	Hot Water Sol.—%	Thujaplicins %	pH Aqueous Extract
0 – 1½	5.0 YR 5/4.5 to 7.5 YR 6/6.5 (Medium Brown)	1.2	.000	4.65
1½– 3	5.0 YR 5/4.5 to 7.5 YR 6/6.5 (Medium Brown)	3.1	.002	4.15
3 – 4½	5.0 YR 5/4.5 to 7.5 YR 6/6.5 (Medium Brown)	5.1	.03	3.90
4½– 6	5.0 YR 5/4.5 to 7.5 YR 6/6.5 (Medium Brown)	6.5	.13	3.70
6 – 7½	2.5 YR 6/4 (Brownish Pink)	8.4	.44	3.80
7½– 9	2.5 Y 8/5.5 (Straw)	10.3	.62	3.70
9 –10½	2.5 Y 8/5.5 (Straw)	12.6	.83	3.70
10½–12	2.5 Y 8/5.5 (Straw)	15.2	1.13	3.60
12 –13½	2.5 Y 8/5.5 (Straw)	20.2	1.15	3.63
13½–15	2.5 Y 8/5.5 (Straw)	22.8	1.22	3.63
12 –13½*	7.5 YR 6/6.5 (Medium Brown)	13.5	.23	3.59

*Sample from the pocket of brown wood surrounded by straw colored wood.
†Colors estimated using the Munsell Book of Color.

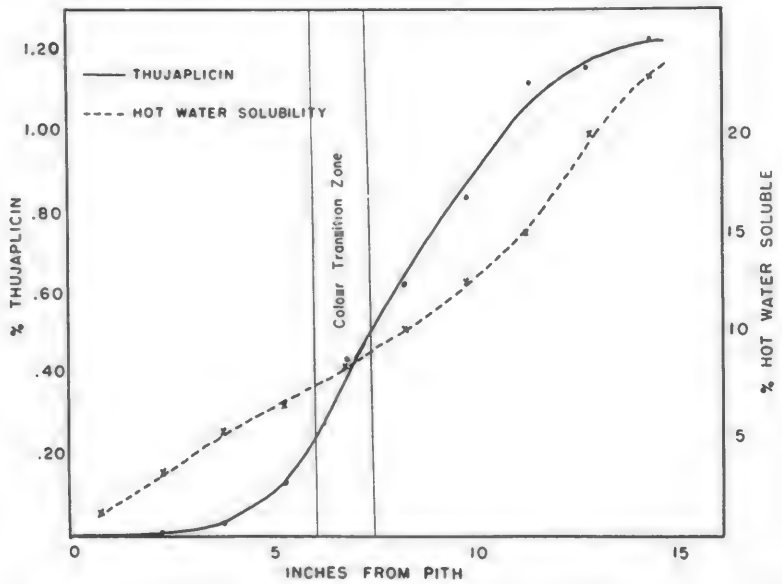

Fig. 3.—Variation of per cent thujaplicin and hot water solubility of tree 1 heartwood with increasing distance from the pith.

It is evident from the graph that the thujaplicin content increased radially more rapidly in the zone of transition from brown to straw colored wood. Further indications of the effect of color change are provided by the analytical results for the included pocket of brown wood. Here, the hot water solubility of 13.5 per cent and thujaplicins content of 0.23 per cent compared with 20.2 per cent and 1.15 per cent respectively for straw colored wood at the same distance from the pith in an adjacent quadrant of the cross-section. This sharp reduction coincident with the color change was not due to a natural tangential variation since in subsequent extensive analytical work on the same butt portion of this tree in conjunction with accelerated laboratory decay tests (6), no appreciable tangential variation of hot water solubility and thujaplicin content was found.

Tree No. 2: This tree, from the same area as tree 1, was 750 years old, of even growth rate, 40 inches in diameter, and contained a core of brown cubical butt rot approximately 4½ inches in diameter. This defect is common in the butt logs of many mature and over-mature cedar. The analytical results are given in Table 3 and graphed in Fig. 4.

In this second sample, the color change was much more pronounced, from chocolate brown to straw through a brownish pink transition zone at 10½ to 11½ inches from the pith. The sharp increase in content of hot water solubles and thujaplicins in this color transition zone is evidenced by the sharp inflection in the plotted curves at that point. Here again, as in tree 1, the outer straw colored heartwood is seen to be rich in hot water solubles and thujaplicin content.

The central five inches of solid wood had a fairly high hot water solubility (8 to 10 per cent) although the thujaplicin content was practically zero. This high solubility together with the dark brown color suggested the presence of decay. A microscopic examination confirmed this. Pit damage and fungal mycelia were present in the wood seven inches from the pith.

The figures for pH of the aqueous extracts for trees 1 and 2 indicate a tendency to higher acidity with increasing distance from pith.

Tree No. 3: This tree was 345 years old, 3½ feet in diameter, and 136 feet high, grown at 2400 feet elevation near Dixon Lake, B. C. Five sample cross-sections at increasing heights were obtained as follows:

Sample Height (feet)	Heartwood Age (years)	Diameter (inches)
4.5	325	40
46	266	24
66	226	22
86	216	18
106	180	9

This tree had a dead top, a common occurrence with this species in all regions. In this case the tree was dead above the 106-foot level. It also had a core of rot at the butt 13 inches in diameter. No extensive color variations were noted, the heartwood being a fairly uniform light brown color except in the butt; near the core of butt rot the color was a dark brown. Analytical results for water-soluble phenols as well as for thujaplicins and hot water solubility are reported in Table 4.

The thujaplicin figures for the butt section of this tree were similar to those of tree 2, which was the same size but twice as old. However, the butt hot water solubilities were quite different; those for tree 3 were about one-half those of tree 2 except in the 147- to 174-year growth period sample (12 to 13½ inches from the pith). Although in this portion the solubility was approximately twice that of adjacent wood, there was no corresponding sharp increase in thujaplicin and water-soluble phenols content. This suggested that the high solubility might be due to incipient decay, a suspicion increased by the slight discoloration in that area.

Considering the analytical results for all cross-sections of this tree, the figures for water solubility, thujaplicin content, and water-soluble phenol content conform to a general pattern of increasing concentration with increasing distance from the pith and overall decrease with increasing height in the tree.

Trees 4, 5, 6, 7 and 8: Tree 4 was a pole cut in North Vancouver, B. C., at 300 feet elevation. Trees 5, 6 and 7 were also in the pole class and were cut at Wilson Creek near Slocan Lake, B. C. at 3500 feet elevation. Tree 8 was a sapling cut on the University of British Columbia campus, Vancouver, B. C. The particulars of these tree samples are given in Table 5.

In preparing the samples for analyses in these small trees, it was necessary to vary the size of the radial increments somewhat. Therefore for these trees the average distance of the test samples from the pith is reported along with the analytical results in Table 6. In the case of the upper sections and the sapling it was necessary to use the whole cross-section and to divide it into radial increments by appropriate use of a band saw. For

Table 3.—ANALYSES OF BUTT CROSS-SECTION FROM TREE NO. 2
(percentages are based on moisture-free wood)

Distance from Pith (inches)	Color	Hot Water Sol.—%	Thujaplicin %	pH Aqueous Extract
0 – 4½	(Dark brown crumbly butt rot not analyzed)			
4½– 6	5.0 YR 3.8/2 (Chocolate Brown)	7.8	.009	3.80
6 – 7½	5.0 YR 3.8/2 (Chocolate Brown)	9.2	.013	3.70
7½– 9	5.0 YR 3.8/2 (Chocolate Brown)	9.3	.014	3.63
9 –10½	5.0 YR 3.8/2 (Chocolate Brown)	10.6	.019	3.52
10½–12	2.5 YR 5.5/4 (Brownish Pink)	19.6	.12	3.50
12 –13½	1.5 Y 8/4 (Straw)	21.5	.58	3.50
13½–15	1.5 Y 8/4 (Straw)	21.4	.61	3.50
15 –16½	1.5 Y 8/4 (Straw)	23.3	.61	3.52
16½–18	1.5 Y 8/4 (Straw)	23.0	.67	3.55

Table 4.—RADIAL ANALYSES OF CROSS-SECTIONS AT INCREASING HEIGHTS, TREE NO. 3

Sample Height (feet)	Period of Growth (years)	Av. Age of Sample (years)	Hot Water Sol.	Thujaplicin	Water-sol. Phenols
			In per cent of moisture-free wood		
4.5	0– 82	No sample First 7½ in. brown crumbly butt rot.			
	82– 99	221	7.6	.11	4.5
	99–123	201	12.2	.15	6.8
	123–147	177	11.0	.51	9.2
	147–174	151	21.9	.41	8.7
	174–207	121	13.2	.50	11.8
	207–239	99	11.6	.58	11.5
	239–270	57	12.6	.60	11.9
	270–305	24	13.9	.63	13.0
46	59– 73	246	3.1	.011	1.3
	73– 90	230	4.1	.007	1.9
	90–108	213	5.8	.011	3.0
	108–143	186	6.9	.036	3.8
	143–176	152	7.4	.036	4.5
	176–231	108	7.2	.36	5.8
	231–292	50	10.5	.52	7.5
66	78– 93	226	4.2	.025	2.4
	93–113	209	4.9	.035	2.5
	113–133	189	5.9	.038	2.8
	133–155	168	6.7	.052	3.5
	155–186	142	7.3	.056	4.5
	186–241	99	7.6	.042	4.2
	241–305	39	14.5	.035	10.1
86	109–124	195	4.2	.018	2.0
	124–141	180	4.7	.021	2.3
	141–168	157	6.0	.025	3.4
	168–216	120	8.2	.032	4.5
	216–250	79	8.9	.030	4.7
	250–312	31	16.0	.036	11.2
106	145–165	157	4.8	.016	1.7
	165–205	127	6.0	.019	2.7
	205–310	55	19.2	.033	16.4

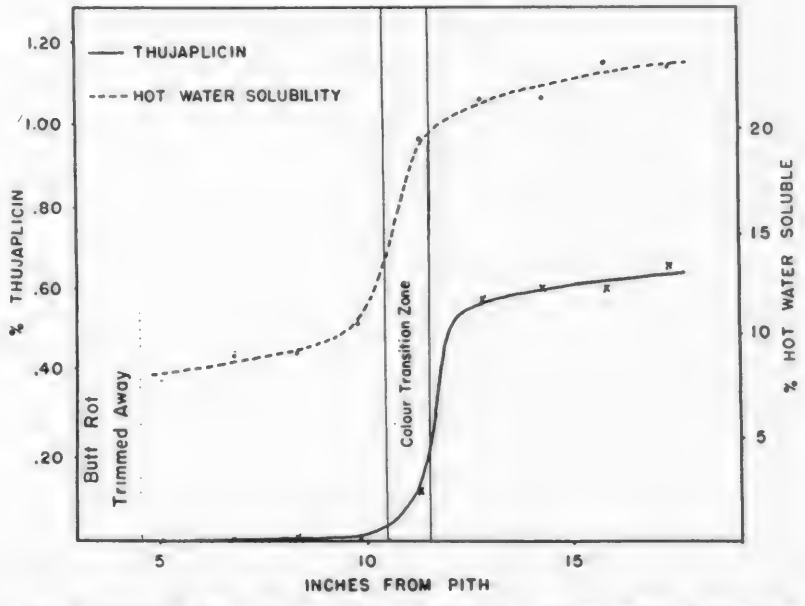

Fig. 4.—Variation of per cent thujaplicin and hot water solubility of tree 2 heartwood with increasing distance from the pith.

tree 7, only one test sample was analyzed at each height and these were taken from the same growth period for each cross-section. The results are given in Table 7.

In general, the figures for content of thujaplicin and water-soluble phenols in the new heartwood of these young trees are much lower than those for the new heartwood in mature trees such as 1 and 2. However, they are in the same range as those found for the inner heartwood of the older trees which represents their early growth period. This suggests that during the natural growth of the tree there is little change with increasing age in the content of these natural preservatives in the heartwood, once it has been formed.

The hot water solubility figures for these trees are also in the same range as those reported by Cartwright (4) for a 65-year-old 80-foot high, 2-foot diameter cedar grown in Scotland and exhibit the same general pattern of increase towards the outer heartwood and decrease up the trunk. The figures for the water-soluble phenols and thujaplicins show a similar variation but in the case of the thujaplicins the change is much more pronounced.

Color Variations

To obtain additional data on variations in relation to color of the wood, three high quality shingles from the sound butt heartwood of mature trees exhibiting typical color variations and uniform growth rate were selected at a local shingle mill. Sections of these shingles with the borders of the various zones marked with a pencil line are shown in Fig. 1. Since the middle straw colored zone (zone 3) of shingle 3 was approximately 10 inches wide, only the outer 1 inch wide portion adjacent to zone 2 was used to prepare the analytical sample. In all the others, the whole width of each color zone was used. The analytical figures thus represent the average content across the zone. Zone 1 in each shingle was the outermost heartwood adjacent to the sapwood. The results are given in Table 8 and are compared graphically in Figure 5.

In every instance, just as was the case in the seven samples cited in the introduction, the hot water solubility of darker brown wood was less than that of lighter colored wood adjacent to it. The variation of the thujaplicin content and of the hot water-soluble phenols followed the same pattern. In the case of the thujaplicins the differences between color zones were very pronounced. For example, in shingle 1 the change in hot water solubility from zone 2 to 3 was less than 50 per cent while that of the thujaplicin content was in excess of 500 per cent.

The results of comparing the water-soluble phenol figures with those of hot water solubility (column 9, Table 8) are of interest. They show that these polyphenols represent a smaller proportion (60 to 75 per cent) of the total hot water solubles in the brown wood than they do in the adjacent light wood (80 to 100 per cent). An inspection of Tables 4 and 6 shows that this proportion also varies radially, there being a general increase from the pith towards the outer heartwood. Thus it is apparent that the thujaplicin contents and the hot water solubility figures by themselves are not an adequate assay of the relative content of natural preservative substances in the wood.

In these samples, as in the case of trees 1 and 2, and in numerous other miscellaneous samples examined during development of the analytical methods, the outer straw colored heartwood was rich in thujaplicin and water-soluble phenols.

Discussion

The results, in general, show that in western red cedar the hot water solubility of the wood and the content of the natural preservatives, the thujaplicins and the water-soluble phenols, are subject to wide variation. Within a tree they follow a general pattern of increase from inner to outer heartwood and of decrease with increasing distance up the trunk. This confirms the work of Cartwright (4) who found a similar pattern of variation for the hot water solubility and

Table 5. SAMPLE DESCRIPTION, TREES 4 TO 8

Tree No.	Overall Height (feet)	Overall Age (years)	Sample Height (feet)	Diameter (inches)	Heartwood Age (years)
4	80	49	2	12	41
			60	5	14
5	81	92	1	15	80
			42	8.5	41
			62	5	29
6	89	82	1	16	76
			33	8	41
			60	5.5	15
7	81	84	2.5	15	76
			38	7	43
			55	5.5	26
			67	3	11
8	22	20	1	6	14
			3	5.5	12
			9	5	8
			15	4.5	4

Table 7.—EXTRACTIVE CONTENT OF SIMILAR GROWTH RINGS AT VARYING HEIGHTS, TREE NO. 7

Sample Height (feet)	Period of Growth (years)	Av. Distance from Pith (inches)	Hot Water-Sol.	Thujaplicin	Water-Sol Phenols
			In per cent of moisture-free wood		
2.6	66–76	6.3	5.71	.096	4.1
38.1	66–76	2.6	3.34	.014	1.7
55.4	66–76	1.6	3.42	.011	1.9
67.0	66–76	.45	5.44	.007	3.8

Table 6.—RADIAL ANALYSES OF CROSS-SECTIONS AT INCREASING HEIGHTS, TREES 4, 5, 6 AND 8

Sample Height (feet)	Period of Growth (years)	Av. Distance from Pith (inches)	Hot Water-Sol.	Thujaplicin	Water-Sol Phenols
			In per cent of moisture-free wood		
Tree No. 4					
2	0–14	.88	5.5	.074	3.5
	14–26	2.63	8.5	.25	6.0
	26–41	4.38	13.3	.49	12.8
60	29–34	.44	5.6	.028	3.4
	34–38	1.9	6.5	.077	3.6
	38–42	1.56	5.0	.081	3.8
Tree No. 5					
1	0–22	1.0	4.9	.038	2.9
	22–34	3.0	5.4	.10	4.4
	34–47	5.0	7.5	.24	5.4
	47–80	6.75	9.2	.27	8.5
42	35–50	.81	4.1	.014	2.0
	50–76	2.44	5.4	.12	3.4
62	52–67	.5	3.1	.007	1.8
	67–81	1.5	2.4	.025	1.7
Tree No. 6					
1	0–21	.75	8.1	.063	6.7
	21–37	2.25	9.5	.20	8.0
	37–53	3.75	11.5	.20	10.2
	53–76	5.25	12.0	.28	11.0
33	29–44	.75	4.4	.014	2.4
	44–70	2.25	5.6	.065	3.8
60	50–63	.47	4.7	.002	2.5
	63–75	1.41	5.3	.05	3.3
Tree No. 8					
1	0– 6	.4	6.2	.09	5.1
	6–10	1.0	6.1	.12	6.0
	10–14	1.7	7.1	.18	7.1
3	2–14	3.5*	7.0	.15	7.0
9	6–14	3.0*	4.3	.05	4.1
15	10–14	2.5*	5.2	.08	5.1

*Diameter of the heartwood, all of which was used as sample in these cases.

decay resistance of a western red cedar grown in Scotland.

The concentration of these materials in the wood of young trees is low, and as might be expected, is similar to that of the inner wood of mature trees, the portion representing their early growth period. Apparently as the tree matures, its ability to manufacture the fungicidal extractives is considerably increased with the result that the outer straw colored butt heartwood of mature trees is rich in these chemicals.

In the present extensive coastal shingle manufacturing operations, much of the wood used belongs to this category. Mill waste in shingle production is extensive, accounting for more than 50 per cent of the volume of the log and a substantial proportion of this waste consists of solid "spalts" of outer butt heartwood. These along with the waste are usually disposed of by incineration at some cost. It is evident that research on the chemistry and uses of the thujaplicins and other water-soluble extractives might prove profitable for this industry.

Superimposed upon the pattern of radial increase of natural preservatives is a marked dependence on color. Thus within cross-sections containing color variations, the content of these chemicals in darker brown colored wood is much less than that in adjacent light colored wood. Where zones of approximately equal color are present in the section, that nearer the sapwood has a higher content in accord with the radial pattern of increase.

The cause of the color variations in the sound heartwood is not known. It is possible the darker brown colored zones with lower extractive content are laid down as such during the formation of the heartwood or they may arise later from chemical changes induced in the extractives by the enzyme systems of micro-organisms. In this latter case it is not necessary that the micro-organisms concerned be of the wood-destroying type. The water-soluble phenols of cedar are polyphenols of the type oxidized to darker brown less soluble material by polyphenol oxidases such as are secreted by the non-decay producing fungi imperfecti as well as white rot fungi.

It is significant that Eades and Alexander (5) found in a large number of samples of sound wood that whereas light colored cedar heartwood showed almost complete absence of micro-organisms, the darker wood in every case was by comparison infested with them, containing bacteria, yeasts, moulds, and fungi imperfecti. Experimental examination of this hypothesis that in the browner zones the toxic extractives have undergone a conversion to more highly oxidized less water-soluble forms of darker color due to enzymatic action is, of course, required.

It must be emphasized, in respect to color variations, that the results reported herein have reference only to true heartwood. In certain interior areas of British Columbia and the northwestern United States, a color variation in cedar consisting of alternate concentric bands of light colored and brown colored wood when shown in cross-section is fairly common. It is perhaps best described as an "archery target" pattern. In this material, the light zones are similar in appearance to sapwood, being almost white, and are readily distinguished from normal heartwood exhibiting a light straw color. They are sometimes referred to as "internal or included sapwood". Field observations of decay patterns as well as laboratory test studies (7) indicate that these zones have no more resistance to decay than normal sapwood. Chemical studies to be reported in a separate paper (10) support the view that they are included sapwood in which the normal process of enrichment with extractives during heartwood formation has not occurred.

It is apparent that wide variations in decay resistance parallel to the variations in concentration of toxic extractives reported herein occur in western red cedar. As already noted, Cart-

Table 8.—EXTRACTIVE CONTENT OF SHINGLES BY COLOR ZONES

Shingle No.	Width (in.)	Zone* No.	Zone* Width (in.)	Color (Munsell)	Hot Water Sol.	Thujaplicin	Water-Soluble Phenols	Water-Sol. Phenols in % of Hot Water Sol.
					In % of moisture-free wood			
1	6.9	1	1.35	Light straw 10 YR 8/4.5	18.2	.76	17.6	97
		2	1.26	Brownish pink 6.0 YR 6.8/4	16.2	.16	16.0	99
		3	1.1	Medium brown 7.5 YR 6.5/5	9.7	.03	6.6	68
		4	1.35	Pinkish brown 6.0 YR 6.3/6	11.2	.05	7.7	69
		5	1.84	Straw 10 YR 8/5	13.9	.43	10.0	72
2	9.6	1	1.6	Light straw 10 YR 8/4	19.5	.68	18.1	93
		2	.6	Brownish pink 6.0 YR 7/4	16.2	.31	14.8	92
		3	1.25	Medium brown 7.5 YR 6.5/5	13.6	.08	8.8	65
		4	.7	Pinkish brown 6.0 YR 7/4	13.9	.26	10.0	72
		5	3.65	Straw 10 YR 8/5	15.5	.53	12.6	81
		6	1.8	Brown 8 YR 6/4	11.1	.05	6.6	59
3	14.0	1	1.7	Light straw 10 YR 8/4	19.5	.67	17.6	90
		2	.75	Medium brown 7.5 YR 5.8/6	15.4	.29	11.0	71
		3	9.83	Light straw 10 YR 8/4	15.9†	.56†	14.7†	93
		4	1.7	Brown 8 YR 6/4	11.4	.24	8.3	73

*Zone 1 is next to sapwood in all shingles.
†These figures represent only the 1-inch wide portion adjacent to zone 2.

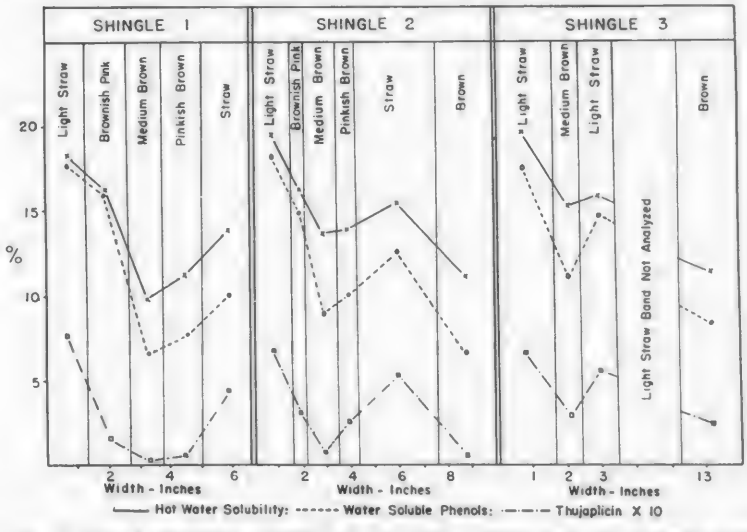

Fig. 5.—Graph illustrating variation of extractive content with color in three western red cedar heartwood shingles.

wright found a correlation between variation in decay resistance as shown in the laboratory tests and the variation of the hot water solubility in a Scottish tree. In work in these laboratories (6), concurrent with that reported here, accelerated laboratory decay studies in conjunction with chemical analyses on one cross-section of a mature tree showed variation of decay resistance with radial distance and with color, in line with variations found in the concentration of the natural preservatives.

Furthermore, while this paper was being prepared for publication, the results of tests of decay resistance of western red cedar poles by Englerth and Scheffer (7) became available. Their results are also in agreement with the chemical results in that the decay resistance within trees varied greatly, the outer heartwood being more resistant that the inner heartwood and the lower trunk more resistant than the upper trunk. It is also significant that the most common defect occurring in standing cedar is a core of decay developing outward from the pith where the analytical figures show the concentration of natural preservatives to be lowest.

Some measure of the effectiveness of the natural preservatives in cedar can be derived from examining the analytical figures for the trees in the pole class (Table 6). The concentration figures for thujaplicin in these young trees in only one case exceeded 0.3 per cent and except at the outer butt were of the order of 0.1 per cent or less. For the phenols, the figures in two cases exceeded 10 per cent at the outer butt, but for the most part were of the order of only 5 per cent or less. Yet the decay resistance of cedar poles has long been recognized as adequate.

By continuing durability studies in conjunction with chemical analysis, it should be possible to establish the minimum natural preservative contents consistent with adequate durability and thus allow some prediction of serviceability from analytical data.

Summary

In western red cedar heartwood, the hot water solubility and the content of the natural preservatives, the thujaplicins and water-soluble phenols, have been determined by analytical methods in a large range of samples. Wide variations were found. Hot water solubilities ranged from 1.2 to 23.3 per cent, and thujaplicin contents from zero to 1.2 per cent.

Within trees, the hot water solubility and the content of thujaplicins and water-soluble phenols followed a general pattern of increase with increasing distance from the pith and of decrease with increasing distance up the trunk.

Where color variations occurred within samples, a change from light to darker color coincided with a reduction in hot water solubility and content of the natural preservatives.

The distribution of content of natural preservatives found in western red cedar is consistent with the natural pattern of decay exhibited in this species and with that which has been found in concurrent accelerated decay studies.

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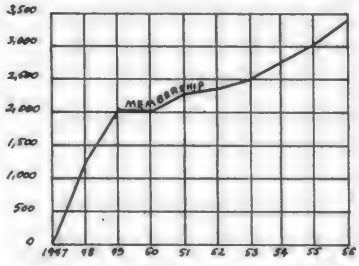
State of the Society, 1956

PITTSBURGH, PA., DEC. 15.—It is customary toward the close of the fiscal year for business organizations to give to their stockholders a report of stewardship over the preceding 12 months, and to point out problems as well as projects that lie ahead. As FPRS stockholders, I am happy to report to you that 1956 has measured up to another year of progress, and that the Society is in sound condition.

R. H. Bescher

I recently returned from our mid-year Executive Board meeting in Madison, Wisconsin. It was, as you will note later, a most productive meeting. Every one of your six Regional Board representatives and four elected officers was present at the one-day meeting. They started in officially at 9:25 a.m. and concluded at 12:05 a.m. the next morning, taking time out only for lunch and dinner. I was proud of the teamwork they exemplified in accomplishing so much in such short time. Now, let's take a closer look at our accomplishments of the past year.

Membership



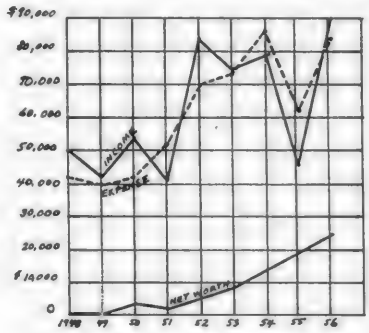
Our goal in '57, 4,000 members.

Our combined membership and subscriptions as of Nov. 9 stood at an all-time high of 3,383, or an increase of 325 over a year ago. An important factor in both this year's growth and in future increased growth is the continent-wide FPRS membership team which now includes some 50 men covering 39 states and provinces.

These workers report to our 13 Section membership chairmen, who in turn are assisted at the national level by the national membership co-chairmen and the Executive Office. Plans are in the works for new membership literature and similar aids to be available early in 1957, in our drive toward 500 new members in the first six months.

Finances

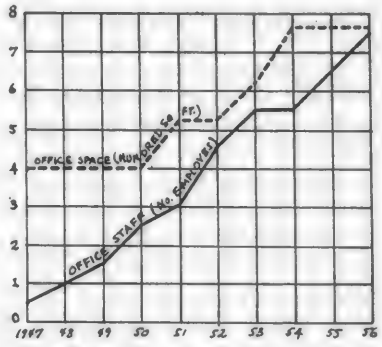
1956 has been a self-supporting year, with our total income approaching $88,000 and expenses $86,000. This is exclusive of donations to the Executive Office building program, and operations of the national meeting. The budget for 1957 calls for $100,000 of income and $97,000 of expenditures. Moreover, the expenses will be tied-in closely with income, to ensure safe and conservative financial growth. Our finances through the 10 years of the Society's growth have, of course, fluctuated; however, the important factor which I would call to your attention is our overall growth in net worth. FPRS' actual net worth, after all obligations are met, and with all material holdings realistically depreciated, today stands at approximately $25,000. Of this, roughly $10,000 is invested in a choice building lot in Madison, $10,000 in building and loan savings, and $5,000 in equipment and cash.



We're putting something away each year.

Our Staff and Office Space

Our Executive Office staff, under the direction of Executive Secretary Frank J. Rovsek, has grown from three persons in 1950 to nine, of which three are part-time. As we have grown, the U.S. Forest Products Laboratory, on whose grounds we are located and with whom we enjoy a cooperative lease arrangement, has generously provided additional space required until we now occupy 900 sq. ft. of office space, not including corridors, etc. However, in view of our expanding publishing activities, attendant storage problems, and more frequent visitors, we believe our staff would benefit by the addition of more working space. This, of course, has been the objective of our long-range Executive Office Building program.

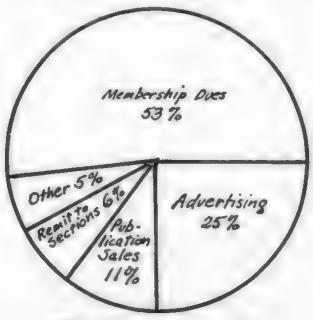


Office space reaching saturation.

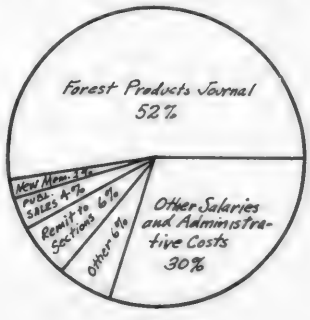
Society Headquarters to Move

Coinciding with the Society's need for greater space has been a growing shortage of space in the Forest Products Laboratory. The building which serves some 400 employes was designed some 25 years ago. Since then both research programs and staff have been doubled, and space needs are critical. Your Executive Board is aware of this need, and while the Laboratory has been most generous about extending our cooperative agreement each year, we know that to continue to occupy our space would be an imposition on it.

Therefore the Board moved, at its recent meeting, to relinquish our space at the earliest agreeable date and to locate suitable nearby rental office space until such time as we build our own building. It is recognized that rental of office space will be both in-



Where the money comes from



. . . and goes.

adequate for future needs, and expensive, and that it will be desirable to get into permanent headquarters as early as possible. The Board also took action to accelerate its long-range building program, under the direction of Southwest Region Board Member Ray Berry, Burney, Calif.

Status of Building Program

Three years ago, after considerable deliberation, your Executive Board took action to establish our Society's headquarters permanently in Madison. There were numerous reasons: Our staff had their homes established there. Madison is a progressive community with numerous research and educational organizations. It is the location of the world's largest fundamental wood research institution—a source of information both to the Society and the industry. Finally, many hundreds of wood industry people visit Madison yearly and would become growingly aware of our headquarters there.

With these factors in mind, the Society was fortunate in being able to locate and purchase a very desirable building site one block from the Forest Products Lab. Having 102 feet of frontage, the lot is valued in excess of $10,000. The next step is to erect our building.

Fund-Raising Program

We are going ahead "full-steam" to raise the funds necessary to erect our new building. As presently envisioned it will be valued in excess of $50,000, of which some $15,000 is to be represented by contributed building materials, lumber, paneling, etc. In addition, we estimate that if we can get an average of $10 to $15 per member in cash in the foreseeable future, we will be ready to proceed safely with construction.

FPRS' philosophy of growth has always been through its membership, building "from the ground up" so to speak. Therefore we are going to appeal to our individual members to be the first to contribute, in whatever amounts they feel warranted, toward the growing fund. Each member should feel that he has been given equal opportunity with any other person or organization to contribute his share. Following the opportunity extended to our individual members, a drive will be made to interest companies in the program. The first step will be the inclusion of a "donation form" along with your dues invoice for 1957, to be mailed to you early in January. We hope you will respond to the call.

Contributions Tax-Deductible

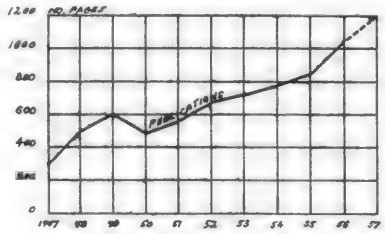
The Society is a duly-registered not-for-profit corporation. Therefore any contributions (and dues) given to it are deductible for income tax purposes by the donors in compliance with section 23 (O) and (Q) of the Internal Revenue Code.

Just a word about the proposed building itself. Essentially a wood building, when erected, it will be a credit to our industry. Our architects have embodied in it the newest and latest forest products and techniques—to symbolize the technological progress for which FPRS stands.

Our Indebtedness to U.S. Forest Products Laboratory

Finally, I would like to publicly acknowledge the deep debt of gratitude which our Society owes to the Forest Products Laboratory, where we have been located since our origin in 1947. Without the support and assistance of the men and women of this great institution, it is doubtful whether FPRS could have attained its present world-wide stature so soon. The Lab and U.S. Forest Service personnel throughout the land have been a prime source of strength, contribution and counsel to FPRS, and we trust they will always continue to be so.

Publications

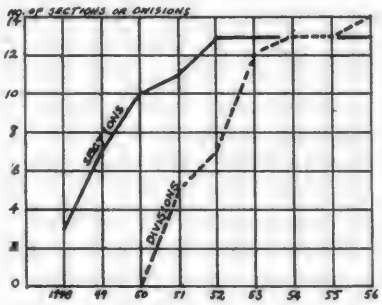


The JOURNAL continues to grow.

In 1956, for the first time, the previously bi-monthly News-Digest, and Journal were integrated into the monthly FOREST PRODUCTS JOURNAL. Not only did we improve our line of communication but we also rendered greater *service*—1056 Journal pages in '56 compared to 852 in '55; or to put it another way, 43 more articles. Plans for '57 provide for another 10 per cent increase in editorial content alone. This points up a little-known fact—FPRS services per member have been steadily increasing since 1947; adding up to more for your money than ever.

Sections

All 13 Sections were active in 1956, thanks to continually improving administration at the Section level. Meetings were better arranged, programmed, publicized, and attended than in previous years. Among several noteworthy meetings were the first Northwest Regional meeting at Lewiston, Idaho; and the Midwest meeting at Rockford, Ill., which attracted over 300 registrants. We continue to have minor problems of conflicting meeting dates, and of lack of coordination between adjacent Sections toward setting up mutually beneficial dates. I hope this can be ironed out in 1957.



Divisions

Just as in the early years of the Society the emphasis was on the need for strong Sections, today the emphasis is on developing our Divisions (or Committees as they were called prior to 1956). The Divisions, 14 of them, plan the technical sessions for our national meetings, prepare "Annual Reviews" of industry developments published in our February JOURNAL, and in general encourage technological progress through committee meetings and correspondence throughout the year. It should always be recognized that our Division officers and personnel deserve equal credit with Section officers for the overall progress of the Society.

Incidentally, if you are interested in participating in the work of one or more of these 14 Divisions, please write to me or the Executive Secretary at Madison.

National Meetings

Our Asheville meeting, with combined official registration of 808, was the second largest in FPRS history. Those of us who participated will agree it measured up on all counts—technically, socially and financially. Our eleventh National Meeting will be at Buffalo, June 24–28, where General Chairman Charlie Lockard and an outstanding arrangements committee have another record meeting in the making. I hope you and your family will be able to take in this educational and exhilarating experience.

This, then is the record of 1956 as we look forward to an even greater year of achievement ahead. I thank you for your courtesy in reading this report and your devoted interest in FPRS. May I wish you and yours a prosperous and happy new year.

RALPH H. BESCHER, *President*

How Southern Pine Mills and Dealers Can Combat Competitive Materials[1]

W. C. HAMMERLE

Executive Secretary, Southeastern Pine Marketing Institute, Savannah, Ga.

Consistent individual effort coupled with organized action by southern pine mills is seen as the most logical, effective answer to combatting competitive materials in house construction. Organization provides the means of assuring product quality and dependability in sufficient quantity to supply market demands. It also supplies the merchandising effort to create increased demand in a highly specialized market.

THE LUMBER MILL and the retail dealer must coordinate in merchandising through established distribution channels if lumber is to retain its place in consumer markets. Economic pressures during war and postwar booms resulted in the production and distribution of inferior lumber; encroachment of producers and retailers in each others' fields; and a build-up in competitive, substitute materials. The entire lumber market, and particularly southern pine, has been affected.

There is no simple answer to the question. The Southeastern Pine Marketing Institute is attempting to meet the problem through quality production, merchandised under a trademark, mill-identified, and correctly grademarked. An older, established association of mills in Arkansas has demonstrated the effectiveness of such action. Mills in Texas, Alabama and Mississippi have organized quality promotion groups based on grade marking. The Southern Pine Association has materially stepped up its trade promotion and public relations programs. However, the bulk of southern pine mills do not participate in any of these constructive efforts.

Organization is a basic need in the southern pine industry. The competition is well organized and financed, and is effectively merchandising its product. This is true of competing woods as well as substitute materials.

The southern pine lumber industry is a big and important industry to the South and to the nation. It employs 250,000 part and full time workers of which 93 per cent are in direct production. In 1954, its total production equalled 23 per cent of the nation's construction lumber requirements. Basically, it is composed of small scale units with 98 per cent of its mills producing under 5 million board feet annually, but accounting for 72 per cent of the total output.

These thousands of small mills are the backbone of the industry, but at the same time its weakness. Highly individualistic, they are strongly competitive among themselves and extremely resistant to merging into unified action against outside competition. Yet, if even one-third of this group would unite with the medium and larger mill groups, they could rebuild the reputation of southern pine lumber and, at relatively little cost to each, effectively conduct a merchandising campaign that would put competitive materials on the defensive. The characteristics referred to are not peculiar to the small mills but apply to many of the medium and larger mills as well.

Do we need to meet competition? The lumber market for the last year and a half has been good. Generally mills have had more orders than they could fill. Why worry about competition when individually you are doing all right? However, it should be remembered that as recently as 1953 and the first half of 1954 the lumber market was down. Southern pine lumber production in 1953 was the lowest since 1945 and just barely above the 1935–39 average—the index years.

It is common knowledge that the traditional outside markets for southern pine have been drastically curtailed and in some cases lost. Contributing factors have been: inequalities in freight rates; lower production costs and better merchandising of competing woods; and poorly manufactured, improperly seasoned or green southern pine. In 1934, 57 per cent of southern pine production was marketed in northern and mid-western states. In 1954 only 27 per cent of southern pine production moved out of the South. Large scale industrial development and general economic expansion of the South have so far been the salvation of the industry. How long will they continue to be?

Home Building Key Market

The biggest market for southern pine lumber is home building and the business trend rises or falls in relation to the volume of home construction. Has production, which is in direct relation to sales, been keeping pace with home construction? Data from the Bureau of Labor Statistics show 927,900 new, non-farm housing unit starts for the first eight months of 1955. This was an increase of 16 per cent over the same period in 1954, and only 6.5 per cent less than in the record breaking year of 1950.

Industry statistics of the Southern Pine Association indicate that southern pine lumber production in the first eight months of 1955 was only 3.5 per cent greater than for the corresponding period in 1954. The increase in southern pine production represented only one-fifth of the increase in the volume of home construction—its biggest market.

While this difference may seem small, from the standpoint of industry production and productive capacity it is significant. With all types of building construction continuing at an all-time high, the use of lumber is not keeping pace. This can be attributed to two factors: (1) the increasing use of other materials, and (2) changes in methods of construction which have greatly reduced the amount of lumber used in home construction.

Construction Methods Affect Use

The trend toward one-story homes and slab-on-ground foundation has reduced the amount of lumber used for sills, floor joists, and subflooring. Less lumber is being used for exterior wall construction. A survey by the U. S. Department of Labor for the first quarter

[1] Presented at meeting of FPRS Florida-Georgia-Alabama Section Nov. 18–19, 1955 in Gainesville, Fla.

The Author: W. C. Hammerle is a graduate of New York State College of Forestry. He was formerly employed by U. S. Forest Service, North Carolina Forest Service, and South Carolina Forest Service; was State Forester for Georgia and South Carolina, Chief Forester of Southern Pine Association, and Editor and Advertising Manager of The Forest Farmer. Hammerle has held his present position since 1954.

of 1954 indicated that 82 per cent of the exterior walls of 1-family houses started were of frame construction. The southern region, with 34 per cent of the housing starts, showed only 76 per cent frame construction of exterior walls—with wood facing used on only one-third of these houses. Sheathing for exterior walls and roof is a market that is dwindling fast. It is the big market for "board" mills which account for a large percentage of southern pine production.

Room For Expansion

These markets are not yet entirely lost and the industry has sound arguments to advance toward retaining them. Changes in modes of living and architectural styling may have eliminated to a great extent the all-wood house, but there is room for expansion in the use of wood in combination with other materials and in new ways adapted to modern design. In fact, there is a definite trend toward its use in combination with other materials for more attractive exterior and interior walls. Also, the need for sun shades, wind breaks, and seclusion screens in modern construction open up another field for lumber.

The structural framework of a house is a highly important factor in its permanence, maintenance, and adaptability to future changes in design and layout. Lumber is the time-tested material which has proven its superior qualities in hurricanes, storms, and floods.

The slab foundation is a combination of cost reducer and concession to style for the low-set house. The raised foundation provides a more comfortable and dependable floor since it lends itself to better insulation from the ground. Termites and decay are not a serious problem with proper construction, ventilation, and preservative treatment of essential elements. Also, costly repairs due to plumbing defects or foundation cracking are avoided.

Lumber sheathing provides the greatest structural strength to the framework and a better base for attaching siding or roofing, and permits changes in the framework without weakening the structure. Initial costs of a timeproven material as against unknown maintenance costs of substitutes is another factor to be considered.

To these briefly mentioned selling points, there is a negative side that has been effectively utilized by the manufacturers of substitute materials—the experience of builders and home buyers with poor quality, carelessly manufactured, unseasoned lumber whether of southern pine or other species. It is not enough to sell just lumber—quality must be the keyword. Remember that anonymous saying: "The bitterness of poor quality lingers long after the sweetness of cheap price is forgotten."

The need is to emphasize the quality features of southern pine, the advantages of higher standards in manufacture, seasoning, and grading, and to convince buyers that good southern pine lumber is worth any difference in price. Dependability is an important adjunct to quality. The charter members, in setting up the Southeastern Pine Marketing Institute, recognized this. In addition to establishing the requirements pertinent to quality, they provided assurance of dependability through trademarking and mill identification of the members' products.

Home Buyer Indifferent

From the foregoing it appears that our job is to reach the home buyer. But how are we going to reach him? The average home buyer is concerned with the end result—the finished home. His primary interest is in attractive appearance, space requirements, and plenty of modern conveniences. He is not too concerned about the structural features—often knows little about them and takes for granted that FHA, VA or other building requirements thoroughly protect his interests in this respect.

The buyer seldom recognizes or is interested in the advantages that lumber offers. Moreover, in the majority of cases, he doesn't have an opportunity to determine the choice of materials for the structural elements because the operative builder constructs the home before it is sold. There are the fundamental reasons why there is a real problem in meeting competition.

Changing the buyer's attitude is a matter of education to overcome indifference and awaken responsibility for his own welfare. Primarily of future benefit, the industry is obliged to conduct consumer education or relinquish the field to competitive materials.

This was pointed out in an editorial in the October 1, 1955 issue of SOUTHERN LUMBERMAN under the heading, "Metals Covet Housing Markets". It referred to a feature article in the trade paper, STEEL, citing the progress already made in increasing the use of steel and other metals in housing; the challenge offered the metal-working industry; the all-metal home as the ultimate goal; and the unqualified statement that, "One thing is certain: The amount of metal-work going into a new house will continue to increase". Whether their ultimate goal will be reached may be questionable, but you can be sure of one thing—the metal industry will spend money on research, advertising and promotion to accomplish it.

The Materials Specifier

The advantages of lumber, particularly southern pine lumber, must be intelligently presented and sold to those who, in varying degree, are the materials specifiers for home construction—the architect, contractor, operative builder, and retail lumber dealer. All of these specifiers are important and none can be neglected, but the key man in this group is the retail lumber dealer.

In an editorial, "The Great Specifier", (September 19, 1955 issue of AMERICAN LUMBERMAN) Arthur Hood analysed the retailer's strong position in this field in relation to architects, contractors, operative builders, and consumers. He concluded that; ". . . when the chips are down, the brand the dealer has in stock and chooses to sell is most often the determining factor". He also noted that some 9,000 dealers engage in some operative building on their own with complete control over materials and brand specifications. Mr. Hood suggests that with this underlying condition, manufacturers and wholesalers would do well to shift their emphasis in promotion to get the retail dealers to stock and sell their brands. The plywood, insulation, and hardboard industries have recognized this fact in their advertising and dealer promotion. Also, the plywood distributors are raising a half million dollars for strictly local retail advertising of direct benefit to retail dealers.

The retail lumber dealer of today is a building materials merchant. Lumber is but one line in his stock which contains nearly all types of directly competing materials. The dealer is the key link in the lumber distribution chain but he is going to handle and sell those materials which are in demand and show a dollar volume profit. Look what has happened to retail yards opened up by manufacturers themselves in recent years. They have been forced to handle competing materials including competing lumber species.

What The Retailer Wants

Numerous surveys have been made to determine what lumber manufacturers can do to meet retailers' needs, keep them in the lumber business, and improve distribution and marketing practices. Some of the points brought out in these surveys are:

Manufacture:

a. Correlate products with consumer needs. Substitutes study specific markets and develop products to meet needs.

b. Better machining, including double-end trimming and eased edges.

c. Correct seasoning whether air-dried or kiln-dried.

d. Eliminate crooked lumber in manufacture and seasoning.

e. Consistent grading practice. An increased interest in grade-marking.

Distribution:

a. Restore established distribution relationship. By-passing dealers breaks down their ability to maintain proper lumber service in their trade area and encourages promotion of substitutes.

b. Maintain a dependable supply of all needed lumber items. Dealer prefers smaller inventory with all items represented for better turnover. Substitutes maintain complete stock supplies near markets.

c. Avoid mixed grades and requiring dealer and his customer paying the higher grade price for the lower grade permissible in the mixture.

d. Adhere to promised delivery dates.

Marketing:

a. More emphasis on promotion of lumber for established and new uses to pre-sell consumers and specifiers.

b. Back the dealer with cooperative, local consumer advertising; educational promotions; and point-of-sale programs to develop effective retail selling.

c. Lumber prices are erratic and unstable—often with no apparent relation to costs. Wide variations occur in short periods of time when no corresponding fluctuations in prices of substitutes

d. Improved lumber appearance—clean, bright, trim, properly packaged for shipment and handling.

e. Back up sales promotion with the quality product.

Retailer's Part

The retail dealer, through point-of-sale contact with consumer and specifier, can do a great deal to promote the use of lumber in house construction instead of substitute materials. The extent to which he merchandises lumber, especially any species or brand, depends on several factors. Some of the major ones are: buyer demand; competitive price; margin of profit; quality of product; dependability of supply; manufacturer's service and cooperative relations; and assistance rendered in merchandising the product, both directly and indirectly.

Fig. 1.—A trademark applied to each piece of lumber tells the wholesaler, the retailer, and the final consumer that he is buying grademarked, trademarked, and mill-identified Southern Yellow Pine.

The southern pine lumber industry is perfectly capable of meeting all of these requirements. Many individual operators have established well-earned reputations in quality and dependability in manufacture and distribution, and to some degree in marketing or merchandising their products. They are, however, continually exposed to pressure from wholesalers and retail dealers to compete price-wise with inferior southern pine; to eliminate grade-marking and mill identification; and to ship partially seasoned lumber to fill orders.

Here is where the retail dealer can perform a real service in building up the reputation of southern pine—and at the same time his own business. The dealer should insist on getting quality southern pine, properly manufactured, machined, seasoned and delivered in first class condition. He should specify that all lumber be grade-marked and mill-identified—and require compliance. Then, dealer advertising and point-of-sale selling of the quality product, citing its advantages and how to identify it, will bring the mills in line and recalcitrant dealer competition as well.

Manufacturers Must Organize

The industry, of course, must produce the quality product to meet these specifications in sufficient volume to supply the demand, and must take the initiative in merchandising the product to create increasing demand.

The rules of the game have already been established. It is only compliance that has fallen down. The individual southern pine manufacturer can correct conditions and meet the requirements in manufacture and distribution. He can do a great deal in marketing his product and effectively merchandising it. But, the most he can do individually is to establish his own reputation and fill demand for his own product to the limit of productive capacity—as long as there is a demand for southern pine lumber. Individually, he cannot exert enough influence on the home building market to offset the effects of inferior lumber and the organized campaigns of competitive materials which are adequately financed to analyze markets, conduct research, develop products to meet needs, influence structural design, and merchandise their products fully.

The logical, effective answer to combatting competitive materials in house construction is consistent individual effort coupled with organized action. Organization provides the means of assuring consistent performance as to product quality and dependability in sufficient quantity to supply market demands, and the merchandising effort to create increased demand in a highly competitive market. These are the requirements necessary to retain the retail dealer as the merchant and specifier of southern pine lumber.

The Southeastern Pine Marketing Institute was organized to carry out these functions. Although a new organization, we have already found out that there is a definite interest in a dependable source of quality southern pine on the part of wholesalers and retail dealers. We are beginning to secure recognition of our SPMI trademark with accompanying mill-identification and lumber grademark.

The Institute's program is designed to represent the responsible pine mills in the Southeast—small, medium, and large. Its compliance requirements are attainable by all. It is a program that is within the reach of every southern pine producer who is interested in the future of his business and the permanence of southern pine markets. Conservative, but confidence building, advertising and promotion emphasizing the SPMI trademark and mill-identification directly tie results into the member mill. SPMI is the answer of a progressive group of southeastern lumbermen to the reputation acquired by inferior southern pine, and to the organized campaigns of competing materials to usurp the home building field.

Split Personality in Forest Products Research[1]

MILTON A. FOLAND

Vice-President and Manager, Pacific National Advertising Agency, Portland, Ore.

Discusses the scope of market research and some basic decisions that must be made before a market study is undertaken. Outlines market research activities and how they can be beneficial to forest products industries. The careful use of market research enhances the work of product research and insures sales for the product.

THE FOREST PRODUCTS INDUSTRY shows a strange split personality in the research field. Millions of dollars are spent on product research. The industry *believes* in product research. But market research is the poor relation in the research picture. While companies reporting to the National Industrial Advertisers Association's 1954 budget survey showed that lumber and lumber products were No. 1 on the list, with 3.9 per cent of sales for the highest ratio in 13 industrial fields, it is no exaggeration to say that companies in the forest products industry spend less on market research than any other industry of comparable size.

What causes such an acute lack of interest in an essential tool of management decision? For one thing, there's still too much of a tendency to be interested only in selling boards and sawdust. True, the industry has been trained to appreciate the advantages of product research. Maybe it's because product research deals with tangible facts and forms. And market research, which deals with the highly intangible factors of human emotions and whims, seems a little too mysterious and unscientific for production-minded folks in this forest products field.

Actually, market research is just as scientific and exact as product research, in its own way. Let's strip all the varnish off market research, get right down to bare wood, and see what we find.

One of the best and simplest definitions of market research is that it's the look you take before you leap! It's a process of "search and research", a constant hunt for new and pertinent facts to shape the future selling and marketing decisions for a company.

Reversing the usual order of discussing and outlining market research, in the order of their importance to organizations in the forest products field the most widely performed marketing research activities are: 1. Analysis of territory potentials. 2. Competitive position of company products. 3. Analysis of market size. 4. Customer acceptance of new products. 5. Variations in territorial yield. 6. New product demand estimates. 7. Economic research. 8. Comparative study of competitive products. 9. Determining the market characteristics. And as would be expected, packaging research is last in the list. There are other general points that might be named but the above are the ones that should be used to successfully market the product you develop.

Now many marketing problems can be solved in a company without resorting to additional fact finding—the facts are there, except they need to be analyzed and management decision applied. More often than not, in today's shifting markets, additional information is needed. Whatever that information is, it will be used for only one purpose—to assemble facts, not opinions, on which to base decisions. In determining how to get that information, if you approach a market research organization the staff might spend several weeks in defining an approach to your problem, in order to establish: What information will be required to solve it? What are logical sources for this information? How should these sources be approached to get this information? How should the findings be presented for management use?

And now that we've probed the scope of market research a little, and what it is and what it does, and have set forth some of the basic decisions that must be made before a market research job is begun, let's look at the one focal point of all market research.

The big concern of market research is "what makes people tick?"; not all people, only those who influence your company's future. These are the people who, because of the market in which they live, the money they make, the lives they lead, become logical prospects for your products.

The greatest asset of market research is its flexibility. It can be expanded or contracted to fit any area, any number or type of people, cover any phase of your product output or services or sales requirements.

Information Sources

Like every other type of work, the market research field uses certain valuable tools of the trade. If you were to start a market research project tomorrow, what would you do first? As noted above, you'd first look for information concerning your project that has been collected by someone else. It's amazing how much data is available just for the asking, if you know where to look for it.

Government departments often have background data and information that can be helpful in giving a base to a market research study. It may take digging to find the facts you want—but what kind of research doesn't?

Industry and business publications offer a gold mine of information on markets and the people in them. All prominent magazines continually keep up-to-date files on the latest development in the particular fields they cover. This data is available to anyone and these publications are most cooperative in helping you find the facts you want.

Research conducted on an industry-wide scale is another fertile field of information. The Forest Products Research Society has been active in uncovering, developing, and evaluating current and coming trends in all phases of the lumber market. The West Coast Lumbermen's Association, the Douglas Fir Plywood Association, the Western Pine Association, as well as special product associations, are basic sources of market research data.

Not as common, but just as valuable, is the research undertaken for individual corporations that is often made available to other companies. A recent example is the study by the Stanford Research Institute on the demand for wood products, made for the Weyerhaeuser organization. Thousands of summaries of this report have been made available to everyone in the industry and other outside organization. This report provides more than market research. It is a long-range forecast that is certainly of interest to

[1] Presented at panel discussion on marketing, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

the entire lumber industry and to nearly every industry in the United States.

What do you do if you can't find the information you want in government, publication, industry, or corporation research? You strike out on your own! This may not be quite as daring as it sounds. You've probably already done the simplest form of market research, but didn't consider it by that name. That is the mail questionnaire —the use of even postcards. The reply card or questionnaire your customer or prospect mails back to your company is market research in its most elementary form. You ask your customer what he thinks of your product and he sends back a reply card or questionnaire filled out with the information you seek. It's simple—it's cheap. The one disadvantage of the mail questionnaire is that you have no control over who mails them back. You may get answers representative of your customers, and you may not. You can't get at complex technical problems in questionnaires of this type, such as a new product or process that may not have been fully developed in your own laboratory.

Another ready source of market research information is the sales and distribution branch of your own company, or your jobbers or wholesalers. All salesmen come in daily contact with customers, and their opinions are bound to reflect general trends. A disadvantage here is that the salesman's own personal reactions will naturally color the facts he reports. If a salesman reports that no one can use this particular grade or finish in Toledo, it may be the truth; and again he may be the type of salesman who mournfully shakes his head and starts his questioning by saying, "I don't think this finish has much of a chance with builders here, do you?"

A much more scientific way to approach a market research project is to call in a market research organization. The tremendous growth in the number of market research organizations in the last 10 years is a positive indication of how much more reliance management is placing in the market research field. Experienced market researchers are trained in their field and their cost is only a fraction of what may be wasted if product style, quality, price, and other characteristics are determined by opinion rather than by facts.

Training in market opinion or poll research has come a long way. The methods are highly scientific—the attitude of research workers is professional.

At one time or another, you've probably heard a voice on the phone say, "Are you listening to your radio or looking at your television set?" Behind this question is a trained research expert. She must call only the names on a certain part of a certain page in the phone book. She has exactly so many seconds to complete a call, and exactly so many calls to make a day. Her report to the research company is postmarked at a pre-determined hour. A slip-up in any step, and her work is thrown away. In every phase of market research, the rules are just as strict and just as well defined.

Instead of contacting a research organization directly, you may prefer to work through your advertising agency, as many large firms do. Companies close to the advertising centers of Chicago and New York increasingly rely on the advertising agencies for much of their market research, because the size of the agencies has encouraged establishment of market research departments or subsidiaries.

If you can sell your company on that idea, choose your agency with the greatest of care. Make sure it understands and appreciates market research and knows how to evaluate it. The agency should have working experience in the market research field, to give you your money's worth, and the agency should have personal contact with outstanding market research organizations, so it can choose the one most suited to your job.

My organization, of course, is sold on market research. We maintain our own research subsidiary, Pacific Marketing and Research, Inc., and are the only advertising agency in the Pacific Northwest with such a market research affiliate.

Although we use this affiliate organization to perform complete market research studies, we look objectively at the purpose of market research before determining the type of organization to do the job. For example, our agency was the first in the Pacific Northwest to use the services of the Stanford Research Institute for a market study for one of our clients in 1949. Stanford, along with several other organizations, has performed a number of major market research projects through us for our clients. A research-minded advertising agency is always looking for better research methods and can give you invaluable help in undertaking any type of market research program.

In many cases, an advertising agency can originate and supervise a market research project from start to finish for a client, on the smallest possible budget. Market research of this type, done in advance of advertising planning and in the early stages of product development, naturally results in much more effective product design, market planning, advertising, and merchandising for a product.

Objective Look at Product

The most important effect of market research is the objective third-party look at your products. The scientific research company looks at your product with the detached eye of a stranger. It's a well-known fact that we often don't really see what is most familiar to us. This objective look gives a new dimension to your thinking. You have the benefit of a fresh mind taking a brand new look at your problem. That in itself is certainly a valuable benefit.

The companies who use market research consistently report that the biggest benefit they derive is having an essential tool with which to work out management decisions. Formulating long-range policy for a company is much easier and much surer with the aid of market research. It continually supplies the vital information on changing demand in relation to supply. Keeping in close touch with market activity is bound to be reflected in the company's profit picture. The company which really believes in and uses market research is always a jump ahead of its competition.

Here are some thoughts on how market research can be used and applied to the lumber and forest products industry:

1. To increase sales of present products, whether it be lumber, hardboard, insulating board, veneer or possible new molded or extruded products not yet out of the laboratory. Market research will provide facts and specifications, advertising and promotion practices and techniques, distribution channels and comparative studies of competitive products.

2. What new products should be manufactured? The outlook and competitive factors of the veneer, plywood, hardboard, insulating board, chip, pulp, paper, molded fiber and wood chemicals markets—not to mention the fields of metals and plastics—must be considered and evaluated. A competitive product analysis and a competing basic raw material analysis are two important instances in which market research can provide facts for management decision.

3. Can present products be upgraded or improved and markets widened? Here again market research can assess sales potential, price, and many other factors which should be known before a production change is made or a plant investment is even contemplated for the change in product.

Market research can give the answer to any combination of questions. It helps you decide where you sell—and what you sell—and helps you decide where and what you *want* to sell. Correct use of market research can save many a misguided effort.

Assuming that you're convinced market research is a valuable function and deserves a place in your company's total research program, the question is: "When should a company start a market research program?" The answer is: "Right now!" You don't need a big budget to get worthwhile results from market research. Don't wait until you can "afford" an expensive program.

The only way to begin is to start. Market research is especially important in this particular time. The move to the suburbs—the do-it-yourself trend—guaranteed annual wage—continuing prosperity—the forecast of an even greater boom five years from now—all of these factors make for rapidly shifting markets. You can't afford to let the market you have get away from you. And you can't be content to merely hold the market you now have. You must be prepared to move fast to move ahead. And market research stands by to show you the way.

Market research actually is the least expensive part of over-all product development. Today, a good product, in itself, is no longer a guarantee of success. The company that develops a new product, spends millions to produce it, and then looks for markets, is making an expensive mistake.

Familiar as lumber is to the average American, he knows little about forest products and their uses. He must be pre-sold on using the new products you develop, before they come on the market. Through market research, in advance of sales, you point the way to *successful* sales for new forest products. It's a much safer way to launch a new product than selling the initial order on a novelty appeal and then wondering why the re-orders don't come in.

It should be noted that there is a lot of market research being done today in the lumber industry. Major efforts are being made by industry associations and government laboratories in product development work, mostly in the lines of specific market research projects. State laboratories are involved as well and universities and colleges come in for their share of credit in this field. And in spite of the low percentage, moneywise, which is spent by the lumber industry as a whole, there are many companies—many of them comparatively small—that are doing effective market research in the forest products field today.

Conclusions

The signs are here now that management in the lumber and forest products field will have to give immediate and real consideration, not in the future but right now, to their markets and to the battle facing some of their products to stay in those markets. There are companies that will not be in business ten years from now because of their failure to watch and evaluate the rapidly shifting market picture.

Each company in the lumber industry today faces plenty of competition from new developments in the forest products field alone, but there is a really competitive battle shaping up in the basic materials market. Some traditional materials such as wood face a real fight, with rapidly growing interest and production in aluminum, magnesium, plastic and other new materials. On top of that, new uses and applications are being found daily for glass, concrete and gypsum in many of the markets now dominated by wood. Paper and other products from wood chemistry complicate this picture further. Even the tendency of large manufacturers to gain control of distribution outlets points out the crying need for market research for many of our smaller lumber products manufacturers.

The careful use of market research enhances the work of product research. The work you're doing today will culminate in a product that must be sold tomorrow. Even pure basic research eventually produces a salable end product. Intelligent use of market research insures sales for that product.

Forest products research is a potent force in the lumber industry. But it will be even more powerful, eventually, as forest products research is teamed with forest market research.

Reeling at the Rotary Lathe

JOHN E. HYLER
John E. Hyler & Associates, Peoria, Ill.

DEVELOPMENT OF VENEER REELING equipment for use directly behind the rotary lathe, and unreeling equipment for use in connection with the rough clipper, has practically revolutionized veneer-handling technique between the lathe and the clipper in many places. Instead of having an excess of veneer accumulating for the clipper at one time while at other times the clipper is waiting for the lathe, the reeling and unreeling method, with the idea of storage between the two operations or machines, entirely divorces the veneer cutting and clipping operations.

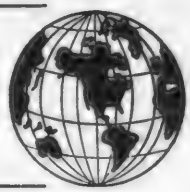
Veneer is wound on a reel at the rear of the rotary lathe as fast as it is cut. When a reel is full, it is placed into storage on a rack or on tracks. The reels are taken from the storage rack as needed, to an unreeling unit which feeds an automatic clipper. After reels have been emptied at this clipper, they are returned to the reeling device, ready for reloading.

A number of filled reels may be awaiting further processing at the unreeler-clipper layout when empty reels are waiting to be filled at the lathe and the reeling station. This method of handling the overall production system is particularly advantageous in veneer mills where other methods of storage and handling cannot be employed.

Reels vary somewhat in different plants but are generally designed to wind to a diameter of not less than 30 inches; some are for reeling to 36-inch diameter. Many times a single reel will hold veneer produced from 2, 3, or 4 blocks, depending upon the diameter of the bolts and general conditions.

However, it is not always advantageous to wind a reel to the fullest diameter it will accommodate. Operators use their discretion in this respect. If a reel has been wound to a diameter less than its capacity but the next block is of considerable diameter so that the reel will not accommodate the entire block, it will be passed on into storage, even though it is wound less than full diameter.

Around the World in Forest Products Research and Development



Reports on Research Program in Australia

Dr. Alfred J. Stamm, U. S. Forest Products Laboratory, recently returned from an extended visit to Australia and neighboring countries, reports briefly on the research program in progress at the Division of Forest Products, C. S. I. R. O.

The Division is made up of eight sections with a combined research staff of 134.

The Section of Wood and Fiber Structure is concerned chiefly with the fine structure of the cell wall, including fibril angle and layer makeup, the effects of tension and compression wood, and the mechanism of cell growth. X-ray and electron microscope techniques are used extensively in these studies. The nature, location, and origin of extractives is a relatively new activity of the section. The section also spends a great deal of time on extending and simplifying means of identification of their vast number of native species.

The Section of Wood Chemistry is working on polysaccharides, chiefly from a rate of hydrolysis standpoint, the constitution of solvent-fractionated lignin, the pulping and making of paper from native species on a handsheet basis, and fiber-fiber bonding and the rheology of paper.

The Section of Timber Physics is doing extensive research on the creep of wood under continued loading. It is also studying the sorption of water vapor by wood and wood components, including a new means of studying water held between 99 and 100 per cent relative humidity, the heat of wetting, the electrical properties of wood, and the development of a new moisture meter.

All of the research of the foregoing sections is fundamental. That of the other five sections is largely applied but the staff has considerable interest in fundamentals. The Section of Timber Mechanics is concerned chiefly with the strength properties of wood and the design of wood structures. It also has underway some semifundamental studies aimed at determining the effect of tension wood on the mechanical properties.

The Section of Timber Seasoning is chiefly concerned with means of seasoning Australia's refractory species with a minimum of collapse. Notable success has already been attained with some species. The section has just completed a rather extensive study of vapor drying by the Hudson process. This approach does not appear to be the answer to their seasoning problems.

The Section of Veneer and Gluing has been relatively inactive since Allan Gordon left them. They have one man who spends almost all of his time as a consultant to industry on veneer cutting, drying, and gluing.

Getting preservatives into resistant species is the chief problem of the Section of Preservation. This section is using an experimental cylinder that will apply pressures up to 1,000 pounds per square inch. It is also seeking to find causes for deterioration of wood under various conditions, and the simplest corrective measures. Practically all veneer, including interior grades, now receives a dip treatment to minimize degrade resulting from a variety of organisms.

The Section of Timber Utilization acts as the main link between the lab and timber industry. It analyzes the availability, production, consumption, and service requirements of various timbers. It makes recommendations regarding the suitability of various species for different end uses, manufacturing processes, and waste prevention and waste utilization. Sawing techniques are now being studied. The use of various forms of waste in particle board manufacture is under consideration.

Other Developments Around the World

West Germany Leads in Forest Fertilizing Practices

The practice of fertilizing forests to increase wood production is considerably more advanced in West Germany than in the United States, according to Dr. E. D. Crittenden, Director of Research, Nitrogen Division, Allied Chemical & Dye Corp., 40 Rector St., New York. He based his observations on a newly translated, 112-page report on German forest fertilization results released last month.

He pointed out that German foresters had, by using fertilizer, increased nursery yields from 100 to 400 per cent and yields of forest trees by 150 to 250 per cent. The report indicates that they have also applied their research findings in practical forestry on a more intensive scale than is known in this country.

The report presents several new ideas, Dr. Crittenden says. One is an ingenious method of "rolling" fertilizer into the forest soil.

Dr. Crittenden noted that the report will be immediately useful to practical foresters, research workers, nurserymen, woodland managers, and others concerned with production, conservation, and modern management. Copies of the report, "The Use of Commercial Fertilizers, Particularly Nitrogen, in Forestry," may be obtained free from Dr. Crittenden at the above address.

Scanning World-Wide Forest Products Publications

ITALY

Recent Costs of Owning and Operating Power Saws. FAO Equipment Notes, Food and Agriculture Organization of United Nations, Rome, Italy. Oct. 1956.

The Cutting Tools Committee of the Woodlands Section, Canadian Pulp and Paper Association, recently carried out an informal survey among its membership to determine the cost of owning and operating gasoline-engine-powered chain saws. The average cost varied from 53 to 78 cents per cord. Formulae used in computing the costs are given, as well as a copy of the 18-part questionnaire.

INDIA

Journal of the Timber Dryers' & Preservers' Association of India. V. 2, Nos. 1, 2. (in English) Seven articles noted.

Treatment of Green Canes by the Diffusion Process. Effect of Copper Sulphate and Mercuric Chloride on Barnacle Larvae. Note on the Standardization of the Polarographic Method of Estimation of Copper Ion. Recent Developments in the Evaluation of the Permanence and Toxicity of Wood Preservatives. Fire Hazard in Timber Structures. Note on the Treatment of Timber Poles by the Boucherie Process. Kiln Seasoning in India, Part VII.

Abstracts From Current World Literature

Particle Board

Bischoff, W. and Huber, W. Die Messung der Dickenquellung and Wasseraufnahme von Spanplatten. [Measuring water absorption and swelling of chipboards.] *Holz-Zbl.* 81 (102), 1955 (1211–2).

Describes experiments showing that both swelling at test points and water absorption differ greatly for boards submerged horizontally and vertically (both methods being permissible under German testing rules). Not only is swelling at the lower ends of the latter greater than at the upper ends, but the total swelling and water absorption are 5–10 times greater after a 24-hour test period. The difference is attributed to the pressure gradient existing along the surface of vertical boards which facilitates the escape of air. The authors describe a third testing method, developed by Messrs. E. Behr, Wendlingen, in which specimens of smaller size, only partly standing in water, are measured and weighed after ½, 1, 2, 3, 5 and 24 hours, the first 5 hours being, according to the authors, the most important for practical purposes. Comparative test results according to the three methods are tabulated for both swelling and water absorption. [For. Abs. V. 17, No. 1]

Waste Utilization

Reineke, L. H. Briquets from woodwaste. U. S. Forest Products Laboratory. Report No. 1666–13, February 1955, 7 pp.

This report is a comprehensive survey of briquetting methods with the emphasis on processes which require no added binder. Wood waste can be compounded into the solid form by the application of high pressure (25000 lb. per sq in) and temperature (above 325° F.). The 'Presto-log' machine made in the U.S.A., performs this process producing 4 in. × 12 in. briquets, the friction developed by the action of the high pressure on the charge of woodwaste providing sufficient heat.

The Swiss 'Glomera' machine and two further American ones work on the extrusion principle and produce pellets suitable for mechanical stoking. The Glomera produces 1 ton per hour and needs 6 to 8 men to operate it. With one type of American machine 1 man can operate 4 machines each producing just under ½ ton per hour. For economic operation, these machines must be kept going 24 hr a day and the woodwaste supply must be near, constant and with 6% moisture content.

Charcoal briquets are discussed and there is a fairly detailed section on binders both of the mechanical and chemical varieties. The combination of wood with other fuel materials as a briquet is mentioned as a possible development. [F.D.C. Tech. Bul. V. 5, No. 30]

Bark—the fabulous waste. *Ind. Eng. Chem.* 48, no. 1: 75–6A (Jan., 1956).

Many companies are now processing bark and finding it a profitable enterprise. Douglas-fir, western hemlock, and redwood barks are examples of the varieties being used to produce wax, adhesives, and hardboard and in oil-well drilling muds, soil conditioners, insulating felts, and numerous other applications. [Bul. Pap. Chem. V. 26, No. 6]

Terry, N. Utilization of sawmill waste for pulp manufacture. *Pulp Paper Mag. Can.* 56, no. 13: 142, 146, 148 (Dec., 1955).

Following a summary of developments in the utilization of sawmill waste and considerations in the purchase of chips made from sawmill residue, the author discusses the process of briquetting, particularly a recent method for making shaving briquets. Tests were conducted comparing the shaving briquets and chips from Douglas-fir and western hemlock, and the difficulties in achieving complete penetration of the compressed shavings and the differences in the pulps produced from shavings and chips are discussed. [Bul. Pap. Chem. V. 26, No 6]

Gordon, J. Techniques in wood utilization. *Am. Forests* 61, No. 12:22–3, 63 (Dec., 1955).

Progress in the reduction of waste in the forest industries is being accomplished by better management of the forests and the utilization of small-size logging and mill cuttings formerly considered waste through new processes for producing such products as hardboard and chipboard. 1 illustration. [Bul. Pap. Chem. V. 26, No. 1]

Properties

World timbers. Timber Development Association, London. Vols. 1 and 2 [1953]; Vol. 3 [1955].

The timbers, some 50 in each volume, are arranged alphabetically under the trade names and there are indexes of these and other common and scientific names. For each timber, the botanical and other names are given with brief notes on the tree and its distribution and details of the physical, mechanical, seasoning and working properties of the timber, its uses and supplies. [For. Abs. V. 17, No. 1]

Noise Abatement

Planned positioning reduces noise cheaply. *Automation Age.* Vol. 1 No. 6, February 1956, p. 2, 3 illus.

Excessive noise, not only leads to general fatigue but impairs the efficiency of the worker. The sensitivity of the human ear decreases rapidly with increasing noise intensity and as it adapts itself too readily to surrounding conditions, the sound memory is too short for comparisons to be made without using instruments.

A portable sound level measure is made which, if carried around a workshop during normal working conditions, can give a contour plan of sound levels. Once this data is available, layout and positioning can be arranged to the best advantage. [F. D. C. Tech. Bul. V. 6, No. 31]

Hardboard

Basler, H. Causes and action of the binding force inherent in fibrous materials as they affect hardboard manufacture. *Transl. Commonw. sci. industr. Res. Organ. Aust.* No. 2416, 1955. pp. 16. 2? refs. Transl. by E. Feigl from *Holz Roh- u. Werkstoff* 11 (8), 1953 (297–302). [See *For. Abstr.* 15 (No. 2057).] Limited distribution. [For. Abs. V. 17, No. 1]

Wood Preservation

End check preventatives pay. *The Timberman,* Vol. 56, No. 12, October 1955, pp. 68, 72.

The results of tests of end sealers and cover boards carried out by three firms in California are reported in this article. Mechanical equipment has been developed for applying the end coatings quickly.

The results for 1 in × 8 in redwood in one series of tests in which both ends were treated with one of five materials were as follows:

Treatment	Saving of timber in board ft per thousand board ft: Air drying	Air drying followed by kilning
Wax emulsion	28	60
Latex with aluminium pigment	–	56
Filled hardened gloss oil	36	41
Polyvinyl emulsion ..	–	23
Drying oil	1	8

[F.D.C. Tech. Bul. V. 5, No. 30]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains over 1,500 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

NEW PRODUCTS—LITERATURE

FPRS News-Digest, Continued

Rip Saw Bulletin

An eight-page bulletin describing features of their new No. 909 multi-rip saw has been released by G. M. Diehl Machine Works, Inc., Wabash, Ind. It points out that this machine is specifically designed for precision, high-speed gang ripping of stock as short as five inches.

Complete specifications are given and 15 different features of the machine are explained. Copies of the bulletin, MRS-909, are available from the manufacturer and all Diehl representatives.

Testing Instruments Described

Instruments for testing paper, plastics, textiles, light metals, and other materials are described in Leaflet P-560, available from Thwing-Albert Instrument Co., Penn St. at Pulaski Ave., Philadelphia 44, Pa. Illustrations and descriptions are given for 31 instruments for testing tear strength, tensile strength, and other properties, as well as fiber classifiers, scales, cutters, meters, and related equipment.

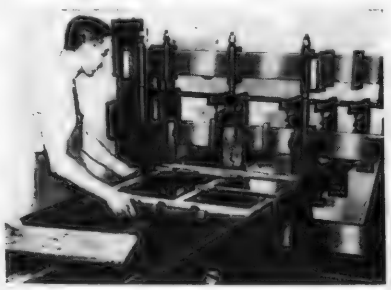
Lab Furniture Booklet

A new line of laboratory furniture is illustrated in the latest issue of Lanco Apparatus news, Vol. 8, No. 1, published by Arthur S. LaPine & Co., 6001 South Knox Ave., Chicago 29, Ill. The bulletin also describes lab equipment such as recording spectrophotometers, gas chromatographs, oven-balance combinations, tank mixers, a variety of new balances, and others.

Crate Feeding Table

A new type feeding table equipped with self-unloading work pushers is available for crate and box manufacture on hand feed stapling cleaters from the Saranac Machine Co., Benton Harbor, Mich. The work pushers are quickly adjustable to set up any crate pattern, thus eliminating the need for special forms previously required for different crates, the manufacturer reports.

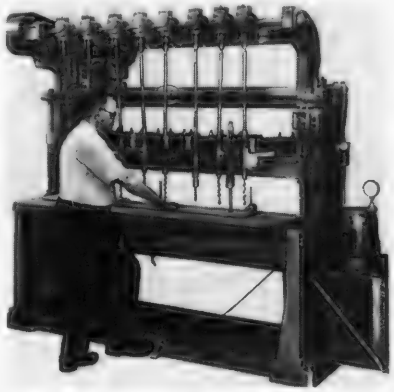
The feeding table, attached to a hand-feed stapling cleater, consists of a pair of special double rails. When feeding work, shook is placed on the work pusher, which is rolled along top rails into position for stapling heads. As heads come down, a precision dimension corrector operates to insure accurate overall work piece dimensions. After stapling, the work pusher releases work automatically, and drops down to a lower set of rails, where gravity assists its return to feeding end of table. Finished work may be delivered directly to a conveyor, if desired.



Pushers are adjustable to handle work from 6 x 10 inches long to over 100 x 315 inches long, depending on machine's width capacity and length of feeding table.

Medium Range Gang Borer

A hydraulic-feed, universal-spindle gang borer for use in medium work range for furniture, cabinet, and other wood products manufacturing has been developed by Greenlee Bros. & Co., Rockford, Ill. It is available



in sizes of 4 and 6 feet, with spindle motor drive to suit individual requirements.

The No. 308 borer, with variable feed and positive control, has a spindle feed rate of 30 to 135 inches per minute. A 4-position foot pedal reportedly provides instant operating control and choice of single or continuous operating cycles. The manufacturer says one of the most important advancements is a stationary table with the spindles feeding into the work piece. The open-back construction allows work to project through or be removed from the rear whenever desired.

Other reported features include: valve arrangement preventing uneven action of the feed stroke, safety relief valve on the pump unit, and spiral-gear top-section for efficient transfer of power from the horizontal spindle drive shaft.

NEW PUBLICATIONS

Office, Public-Building, and Professional Furniture. Advance Report, 1954 Census of Manufactures. Includes selected preliminary statistics from the 1954 census of manufactures, and gives comparative figures for the last previous census covering 1947 whenever available. Sept. 1956. U. S. Dept. of Commerce, Bureau of Census, Washington 25, D. C. 10 cents per copy.

Wooden Containers. Advance Report, 1954 Census of Manufactures. Covers fruit and vegetable baskets, rattan and willow ware, cigar boxes, wooden boxes and cooperage industries. Oct. 1956. U. S. Dept. of Commerce, Bureau of the Census, Washington 25, D. C. 10 cents.

Screens, Shades, and Miscellaneous Furniture. Advance Report, 1954 Census of Manufactures. Reports general statistics, (employment payrolls, cost of materials, value of shipments, etc.) Oct. 1956. U. S. Dept. of Commerce, Bureau of the Census, Washington 25, D. C. 10 cents.

Multi Combination Pole-Type Construction. L. Bonnicksen. Station

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FPRS News-Digest, Continued

Bulletin 557, July, 1956. Agricultural Experiment Station, Oregon State College, Corvallis.

The Nation's Wood Preserving Industry, 1956. American Forest Products Industries, 1816 N. Street N. W., Washington 6, D. C.

Facts about the Nation's Lumber Industry. 1956 Edition. American Forest Products Industries, 1816 N. Street N. W., Washington 6, D. C.

Pulpwood Industry Facts. 1956 Edition. American Forest Products Industries, Inc., 1816 N. Street, N. W., Washington 6, D. C.

Financial Maturity: A Guide to Profitable Timber Growing. W. A. Duerr, J. Fedkiw, and S. Guttenberg. U. S. Dept. of Agriculture Tech. Bull. No. 1146, August, 1956. Available from U. S. Government Printing Office, Washington 25, D. C. 30 cents.

Fifth Biennial Report of the Forest Products Commission, State of Washington. Discusses research program and lists publications of Institute of Forest Products, Dept. of Conservation and Development, 303 Anderson Hall University of Washington, Seattle 5, Wash.

1955 Pulpwood Production in the South. J. W. Cruikshank and J. F. McCormack. Forest Survey Release 47, Southeastern Forest Experiment Station, Asheville, N. C.

Forests of East Texas, 1953–1955. Forest Survey Release 77, Southern Forest Experiment Station, New Orleans, La.

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The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

Partial List of Government Publications of Interest to Architects, Builders, Engineers, and Retail Lumbermen. No. 1081.

List of Publications Relating to Fungus Defects in Forest Products and to Decay in Trees. No. 508.

List of Publications on Wood Finishing Subjects. No. 454.

List of Publications on Mechanical Properties and Structural Uses of Wood and Wood Products. No. 200.

List of Publications on the Growth, Structure, and Identification of Wood. No. 177.

Some Publications on Domestic and Foreign Woods. No. 1479, revised.

List of Publications on Pulp and Paper. No. 444.

List of Publications on Fire Protection. Lists publications on fire test methods, fire retarding chemicals and treatments, and fire behavior of treated and untreated wood, wood products, and wood structures. No. 2065.

Ovelays Promise Better Utilization of Timber. R. J. Seidl. Reprint from 1955 Proceedings, Society of American Foresters.

Special Methods of Seasoning Wood: Boiling in Oily Liquids. Presents a brief description of several methods of seasoning wood in oil and discusses the advantages and disadvantages. Report No. 1665, revised.

Groundwood and Sulfate Pulping and Newsprint Papermaking Experiments on Engelmann Spruce. E. R. Schafer, J. C. Pew, A. Hyttinen, J. S. Martin, and R. M. Kingsbury. Report 1407 (revised).

Treating Wood in Pentachlorophenol Solutions by the Cold-Soaking Method. J. O. Blew. Describes the technique, equipment, cost, and effectiveness of protecting wood from decay by soaking in cold solutions of pentachlorophenol. Report 1445, revised.

Test for Shipping Containers in Revolving Hexagonal Drum Box-Testing Machines. No. 1462, revised.

Why and Where—as an Engineering Material — Wood Is Versatile, Strong, Economical. F. J. Champion. Reprint from Plant Engineering.

Floors, Walls, Die Models, Acoustical Tiles All Prove — Wood Is What You Make It. F. J. Champion. Reprint from Plant Engineering.

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Ivory Pine Co., Dinuba
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Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

IDAHO
Boise Payette Lumber Co., Boise
Ohio Match Co., Coeur d'Alene

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General Electric, Ill. Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Illinois Interior Finish Co., Chicago
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Masonite Corp., Chicago
Mattison Machine Works, Rockford
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Steger Furniture Mfg. Co., Steger

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The Dunbar Furniture Mfg. Co., Berne
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J. I. Wells, Salisbury

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Heywood-Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee

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Minnesota Mining and Mfg. Co., St. Paul
Rilco Laminated Products, Inc., St. Paul
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MISSOURI
Monsanto Chemical Co., St. Louis

MONTANA
Intermountain Lumber Co., Missoula

NEVADA
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NEW JERSEY
National Adhesives, Plainfield
Western Electric Co., Kearny

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Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
The New England Industries, Inc., New York
Oval Wood Dish Corp., Tupper Lake
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Cascades Plywood Corporation, Portland
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Koppers Company, Inc., Pittsburgh
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Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley

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Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

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Kirby Lumber Corporation, Houston
Love Wood Products of Texas, Diboll
Wynnewood Products Co., Jacksonville

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ALASKA
Ketchikan Spruce Mills, Ketchikan

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FPRS Title and Subject Index—Vol. VI, 1956

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The Author Index contains an entry for every author. For articles with a single author, the listing gives author's name, subject, issue number, and page. For articles with two or more authors, the listing for the first author gives all authors' names, subject, issue number, and page; listings for other co-authors refer back to first author. Two or more articles by the same author are listed chronologically.

If the exact title or an author's name is known, an article can be located quickly. If neither the title nor author's name is known, there are many clues by which an article can be found. For example, an article titled High-Temperature Drying of Birch may be found under Seasoning and Birch.

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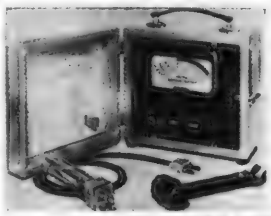

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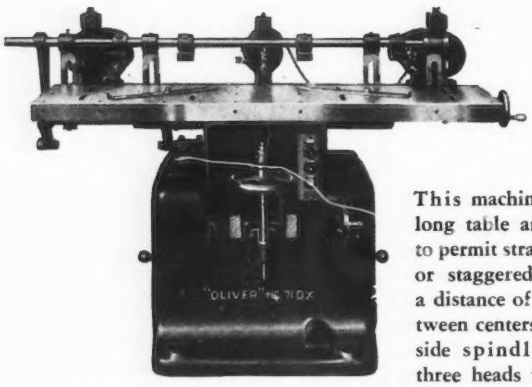

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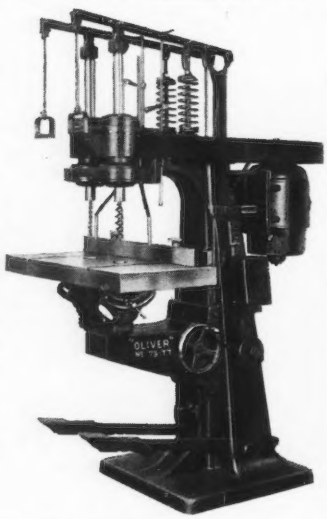

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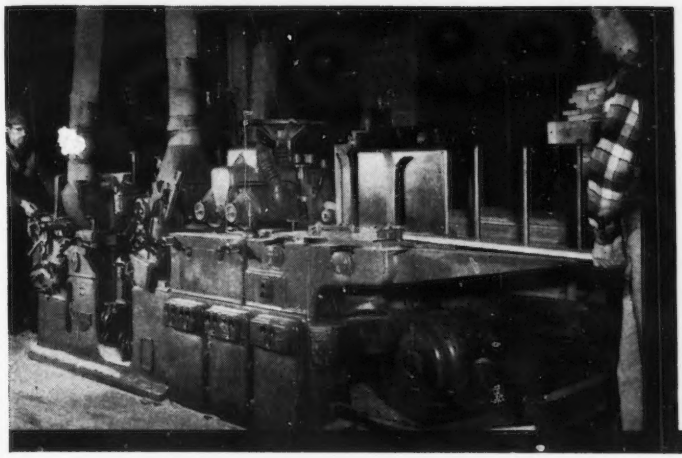

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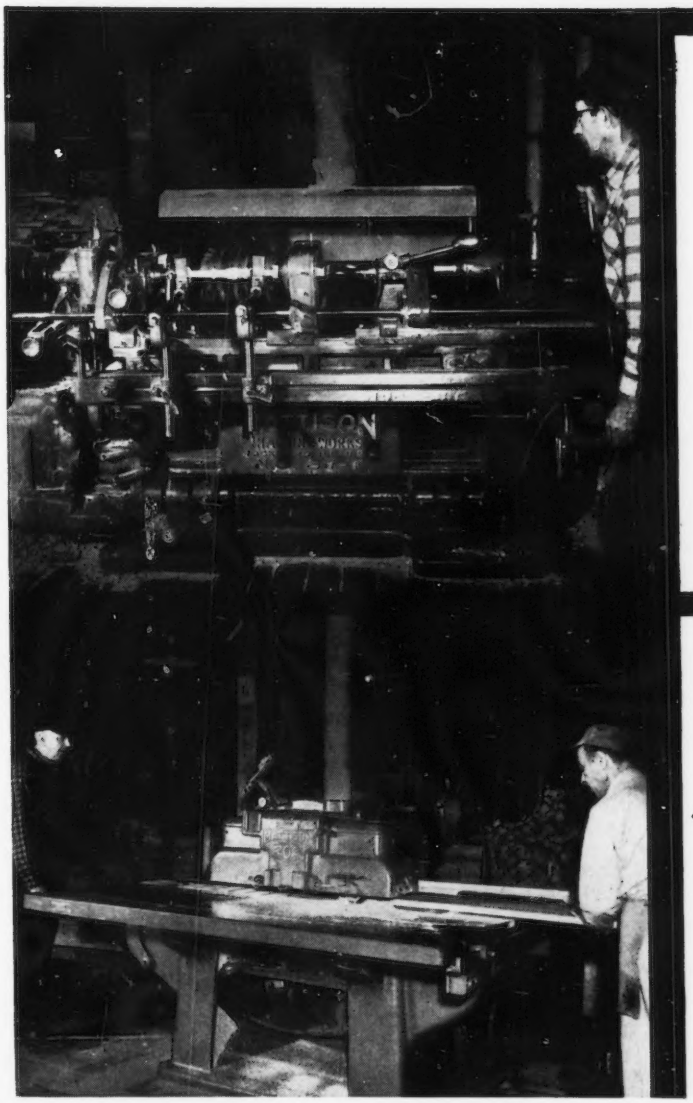

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